

THEORIES OF WEIGHT
IN THE ANCIENT WORLD

*Four Essays on Democritus, Plato and Aristotle
a Study in the Development of Ideas*

BY

DESMOND WHEELER
WEIGHT AND MEAS.

AN ESSAY IN THE RECONSTRUCTION OF EARLY GREEK PHILOSOPHY

BY

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Four Essays on Democritus, Plato and Aristotle
A Study in the Development of Ideas

VOLUME ONE

**PHILOSOPHIA ANTIQUA
A SERIES OF MONOGRAPHS
ON ANCIENT PHILOSOPHY**

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VOLUME XXXVII

D. O'BRIEN
THEORIES OF WEIGHT IN THE ANCIENT WORLD
I

Democritus Weight and Size

An Exercise in the Reconstruction of Early Greek Philosophy

By
D. O'Brien

*Chargé de Recherche
au Centre National de la Recherche Scientifique, Paris*

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1981

VOLUME TWO

PLATO WEIGHT AND SENSATION

The Two Theories of the 'Timaeus'

VOLUME THREE

ARISTOTLE WEIGHT AND MOVEMENT

'De caelo' Book Four: A Reconstruction of Aristotle's Theory

VOLUME FOUR

ARISTOTLE WEIGHT AND MOVEMENT

'De caelo' Book Four: An Interpretation of Aristotle's Theory

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sedi sapientiae
sacrum

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AVANT-PROPOS

Cet ouvrage représente la première de quatre études portant sur les théories de la pesanteur dans l'antiquité. Elle est consacrée à la théorie de Démocrite, chez lequel la pesanteur serait fonction de la taille des atomes. La deuxième aura pour objet le *Timée*, où Platon a eu l'idée, le premier, à mon sentiment, de comprendre sa théorie de la pesanteur dans le cadre d'une théorie de la sensation. La troisième et la quatrième traitent de la théorie d'Aristote, pour qui la conception de la pesanteur fait partie intégrante de celle du mouvement.

Certes, ces trois auteurs n'épuisent point tout ce qu'a pu être l'apport de la culture gréco-romaine sur cette question, comme le laisse deviner confusément plus d'un vestige. Ils nous en livrent pourtant l'essentiel: avant Démocrite, aucun penseur ne me semble avoir cherché à intégrer la notion de pesanteur à un système aussi bien philosophique que scientifique; après Aristote, ce que nous savons de la science antique ne nous laisse guère distinguer de théorie de la pesanteur qui ne soit calquée dans ses grandes lignes sur celles de l'Académie ou du Lycée. En revanche, la critique par Platon de la théorie démocritéenne de la pesanteur, ainsi que la reprise et la refonte de cette critique par Aristote, nous font percevoir chez ces auteurs, à travers la continuité même de leurs pensées, une originalité certaine; si bien que l'historien des idées trouve chez eux, sur ce thème précis, une occasion tout à fait privilégiée d'observer un exemple de genèse et d'évolution des idées dans le temps.

Evidemment on ne saurait entreprendre une recherche de cette dimension sans disposer de conditions de travail exceptionnelles. Je les dois à la générosité du Centre National de la Recherche Scientifique et, dans ce cadre, j'ai eu le privilège, également, de pouvoir fréquenter les séminaires organisés au Centre Léon Robin, à la Sorbonne. Monsieur le Professeur P.-M. Schuhl, membre de l'Institut, qui a dirigé ce Centre durant de longues années, ne m'a jamais mesuré sa bienveillance attentive, et j'ai toujours entendu avec le plus grand intérêt ses aperçus et ses rapprochements stimulants, puisés à la source d'une vaste érudition, et propres à renouveler l'ardeur de la recherche. Monsieur le

Professeur P. Aubenque, qui lui a succédé à la direction du Centre Léon Robin, ainsi que Monsieur le Professeur J. Brunschwig, qui a bien voulu accepter d'assurer mon parrainage auprès du Centre National de la Recherche Scientifique, ont manifesté le même souci que lui de m'assurer une entière liberté intellectuelle, tout en me faisant bénéficier, comme lui, des ressources de leur savoir, et de tout l'acquis, notamment, rassemblé par la tradition, séculaire à Paris, des recherches aristotéliennes.

Je dois également exprimer ici ma reconnaissance pour la cordialité de leur accueil, ainsi que pour les nombreuses remarques et les informations qu'ils m'ont si amicalement apportées sur divers points, à mes collègues parisiens, et notamment à Monsieur le Professeur J. Pépin, et à Monsieur Denis et Madame Françoise Zaslowsky. Je tiens également à exprimer mes plus vifs remerciements à des amis anglais ou américains qui ont bien voulu lire certaines parties du présent ouvrage et me faire part de leurs observations: à Madame K.M. Burnett, à Monsieur le Docteur G.E.R. Lloyd, à Messieurs J.H. Prynne, A. Pugh et W. Stewart, de l'Université de Cambridge, à Monsieur le Professeur J. McGovern, du Département d'Histoire de l'Université de Illinois, à Monsieur S.V. Keeling, Docteur ès Lettres de l'Université de Montpellier, à Monsieur le Professeur J.A. Scott, de l'Université de Newfoundland, à Monsieur le Professeur J.B. Skemp, de l'Université de Durham; enfin, à Monsieur le Professeur W.J. Verdenius, de l'Université d'Utrecht. Que celui-ci trouve ici l'expression de ma gratitude toute particulière pour avoir accepté de publier mon ouvrage dans cette série dont il assume la direction, et qui lui vaut la reconnaissance de tous ceux qui étudient l'histoire de la philosophie antique.

PARIS

ILE SAINT LOUIS 1971, PALAIS ROYAL 1978

INTRODUCTION

Much labour and some ingenuity has been spent on disentangling the literary wreckage of the ancient world, and on reconstructing, so far as the evidence which has survived will allow, the intellectual experience of antiquity. This and the three studies which follow are a contribution to this end.

Naturally, I should not have wished to publish them if I did not think that they came nearer the truth than earlier conclusions have done. But this does not mean that I claim to offer any radically new evidence, nor any methods of analysis that are idiosyncratic or original. The principal texts that I have drawn from are all well-known: Theophrastus *De sensibus*, Plato's *Timaeus*, Aristotle *De caelo*, the commentaries of Simplicius. The methods I have employed for the interpretation of these texts are the traditional ones: scrupulous philological exegesis of individual passages, coupled with a necessarily more speculative account of their relation to their context, and to each other.

And yet one reason for the length of my enquiry is that I do hope to isolate, and in this instance to correct, one major deficiency in the modern study of ancient thought: unthinking submission to the continuing influence of Aristotle.

Recognition of the overwhelming influence of Aristotle on the evidence for our knowledge of the philosophy of the fifth century, and recognition also of the potential prejudice that is introduced thereby into our secondary sources for philosophers who were themselves ignorant of Aristotle, is a lesson that has been well learnt, perhaps too well. What has not been recognised is the continuing influence of Aristotle on our own ideas. Potentially, we are as much at the mercy of Aristotle's ideas as were the historians and philosophers of postAristotelean antiquity, and as was Aristotle himself. The difference is that someone else's prejudice is easier to recognise and to analyse than one's own. There can be no single work for the eradication of modern prejudice in the study of ancient philosophy equivalent to either of Cherniss' monumental works, *Aristotle's criticism of Presocratic philosophy* and *Aristotle's criticism of Plato and the Academy*. It is only repeated study of the individual instance that can make the scholar

aware of the potentially disruptive effect of his own Aristotelean and post-Aristotelean conceptions upon his interpretation of the Presocratic philosophers, and of Plato. And yet if we are to clarify our knowledge of the past to the furthest limits of the restrictions imposed upon us by the availability and the nature of the evidence, then the one lesson is no less important than the other. It is as essential to uncover the Aristotelean prejudice in Aristotle and in Simplicius as it is to uncover the modern, and largely Aristotelean prejudice in Cherniss and in ourselves.

It is in the area of ontology and epistemology that the effect of anachronistic assumption and conception is, I believe, at its most rampant. But the humbler study of early ideas of heavy and light, although these are closely related to early ideas of reality and of perception, makes the interplay of ancient and modern prejudice upon the evidence for the Presocratics and for Plato more manageable and more nearly demonstrable.

Thus the present study attempts to reconstruct the theory of weight that was adopted by Democritus. The evidence is complicated, but the reason why it has been misunderstood lies not only in the intrinsic difficulty of the texts, but equally in the difficulty that modern scholars have in freeing themselves from certain settled habits of thought. 'We may here pause to consider what weight means', writes one scholar in his account of Democritus.¹ The definition which he gives has the authority of Zeller, and the concurrence, perhaps less welcome, of Burnet. It betrays nonetheless, all unwittingly, an Aristotelean influence, which I shall attempt to show is only marginally relevant to the ways of thinking of philosophers in the fifth century, and which is only partially relevant even for Plato.

It is true that the modern interpretation can find ancient evidence to support it. But this confluence of ideas is not accidental. The ancient evidence which Zeller and which Burnet select to support their interpretation of Democritus' theory of weight shows signs, on close inspection, of contamination at precisely the points which render it most palatable to modern prejudice. Instead of adopting the evidence whose categories of thought can be the most easily assimilated to our own ways of thinking, we need to appreciate that the evidence which in this instance is

¹ G.S. Kirk, *The Presocratic philosophers* (Cambridge, 1957) 415.

historically stronger requires a re-alignment of our habitual conceptions, if we are to read its lesson aright.

So it is also with the subject of my second essay. The interpretation of Plato, no less than that of Democritus, has been drawn into the circle of Aristotelean preconceptions. At first, this is surprising, since Plato's work on physical philosophy, the *Timaeus*, has survived complete. The fact that even with the survival of the text Aristotelean ideas have infiltrated into the modern interpretation of Plato's theory of weight, no less than into that of Democritus, is a striking indication that the dominating influence of Aristotle on our understanding of the philosophy of the ancient world is not solely the result of our dependence upon Aristotelean sources for philosophers whose original writings have been lost.

The *Timaeus* is for the most part free from the aporetic and from the dramatic qualities which—sometimes fortunately—hamper any simple reduction of Plato's ideas to a non-dialogue form. But the extremely intricate and enigmatic character of the *Timaeus*, coupled with the 'mythical', or perhaps one should say the analogical, nature of many of Plato's leading concepts, leaves plenty of scope for disagreement and misunderstanding. The interpretation of Plato's analysis of heavy and light I think provides an extreme but not a unique example of the overriding influence of Aristotelean ideas on modern commentators—Martin, Archer-Hind, Taylor—who think that they are simply repeating Plato's theory when all unconsciously they are in fact clothing Plato in Aristotelean ideas which certainly in this case destroy the intricacy and the balance of Plato's original intention.

Latent Aristotelean preconceptions have so far, I believe, concealed the real nature of Plato's theory of heavy and light from the modern reader: paradoxically, it is Aristotle, rightly understood, who helps to provide the cure. 'Aristotle in his criticism of Plato's theory . . . simply ignores the whole point of it from beginning to end': so writes Archer-Hind with a kind of righteous impatience.¹ But his words apply only to himself. Aristotle is not of course impartial. Plato, or Platonism, is for him an active rival. He criticises what he sees as the fatal flaw in Plato's theory, and

¹ R.D. Archer-Hind, *The 'Timaeus' of Plato, edited with introduction and notes* (London and New York, 1888) 228–9.

ignores much of the rest. But the Plato whom Aristotle criticises is at least distinct from his critic. The Plato whom Archer-Hind presents to us is in large part the product of Archer-Hind's own Aristotelean imaginings. And that is why Aristotle's criticisms seem to Archer-Hind—and to Cherniss and to Solmsen—to miss the mark. The target has been placed too close. Aristotle's criticisms are aimed farther afield: he could not easily have criticised the figment that Archer-Hind has placed before him without inflicting fatal injury upon himself.

The criticisms which Theophrastus makes of Plato have suffered in the same way. We have to reconstruct Democritus' theory in part from the summary and criticism which Theophrastus provides of it in the *De sensibus*. For Plato, we have the original expression of the theory, as well as the summary and the criticism which Theophrastus supplies. It is alarming, and chastening, to find that, even when the original text survives, Theophrastus' criticisms have been, as I believe, misunderstood. The reason, I shall argue, is the same as in the case of Aristotle. Taylor unconsciously adopts a heavily Aristoteleanised interpretation of Plato. He therefore misconstrues Theophrastus' attack upon Plato as exegesis and not as criticism. The critical constructions which Theophrastus advances are intended as a refutation of Plato's theory. They are taken by Taylor as exegesis, as a direct statement of the theory itself. For Taylor is unable to see how anyone could *not* think as Aristotle does. The points of Aristotelean theory which Theophrastus offers as a refutation of Plato Taylor is therefore unable to see except as a direct statement of Plato's own theory. Taylor does not see that his own Aristoteleanised version of Plato's theory leaves no room for the radical criticism of Plato which Theophrastus repeats from Aristotle.

This complexity in part explains the length of my enquiry. My study of Plato has to include four chapters devoted to an analysis of the criticisms which Aristotle and which Theophrastus make of Plato. I include these partly of course for their own sake. But I also consider as confirmation of the interpretation which I offer of Plato that it affords the criticisms which Aristotle and which Theophrastus make of Plato a proper foothold in the text of the *Timaeus*. We need to be able to read the *Timaeus* with the eyes of Aristotle, if only in order to avoid reading into it a reflection of Aristotle.

By a significant paradox, it is not only Plato and the Presocratics who are victims of the distorting influence of Aristotle, in the ancient and in the modern world. Aristotle himself, as my third and fourth essays I hope will make clear, suffers as a result of the Aristotelean ways of thinking that we unconsciously cast upon his predecessors. The closer our interpretation of the Presocratics and of Plato is drawn into an Aristotelean frame of reference and of assumption, the less room there is for Aristotle's own ideas to take on their proper scope and balance, and the more difficult, indeed impossible, it becomes for us to discover the alignment of interest, and the polemical intent, of Aristotle himself.

For the extended analyses and criticisms which Aristotle provides of his predecessors and of Plato are not purely historical or doxographical in their purpose. Even when Aristotle presents earlier ideas as in radical opposition to his own, careful analysis shows that nonetheless Aristotle's own ideas have taken on a significant part of their form and their purpose, not only from the common ground that still inevitably exists with earlier ways of thinking, and with Plato in particular, but no less from the attempts that Aristotle deliberately makes to circumvent the fallacies that he sees in the ideas of his predecessors.¹

Here again it is in the more speculative fields of Aristotle's epistemology and ontology, in his conception of active mind and the unmoved mover, that this commerce with the ideas of his predecessors most radically affects the final form of Aristotle's theory, and yet has proved opaque, I believe, to modern methods of analysis and interpretation. But here again Aristotle's conception of heavy and light, portrayed at length in the fourth book of the *De caelo*, illustrates the principle that I have in mind in a more restricted but also in a more nearly demonstrable form. The precise content of Aristotle's criticism of Democritus is integral to Aristotle's own attempted establishment of criteria of differentiation for elements with absolute and with relative weight. It is no accident therefore that in the *De caelo* Aristotle criticises Democritus and Plato at some length, after as well as before the exposition of his own theory of weight. For it is in the attempt to

¹ There are some useful general remarks on this subject by P. Aubenque, 'Physique aristotélicienne et langage', *Archives de philosophie* 31 (1968) 125–32, esp. 126–7.

distinguish his own ideas from those of Democritus that Aristotle is driven furthest in the application of his own criteria of weight; and it is as a result of the attempt to rescue his own ideas from the criticisms that he has made of that version of Democritus' ideas which he sees as most nearly approaching his own that Aristotle is led, or so I shall argue, to abandon weight as a quantitative criterion for the differentiation of the four elements, and to adopt instead a conception of weight which leads to qualitative differentiations, of the kind that we find employed as the foundation for his theory of the identity of the elements in the *De generatione et corruptione*.

This adds a fresh complication to the methodical study of the evidence. The hazards of approaching the study of the Presocratics through a study of Aristotle are compounded by the need for a clear understanding of Presocratic and Platonic ideas in order to appreciate precisely the drift of ideas in Aristotle. This explains, and I hope will in part justify, the sequence of argument in my studies of Democritus and of Aristotle. My study of Democritus begins with three chapters devoted to Aristotle. My reconstruction of Aristotle's theory will conclude with a series of chapters devoted again to Aristotle's criticism of Democritus. The inevitable circularity in the presentation of the evidence could obviously lead to a circularity in the argument. I hope that I have avoided this. If I have not, then it has not been through any lack of consciousness of the danger.

A final reason for the scope, and for the length, of my enquiry is that I have tried to add to it an element of interpretation, as distinct from simple reconstruction. The labour and the hazards of an enquiry where the evidence is fragmentary, enigmatic and circuitous afford an obvious temptation to stop short at trying to establish what individual philosophers said and thought. It may seem a work of supererogation to try to interpret the results: and in any case how are we to do so?

There is, I think, something naive, and unpalatable, in seeking to interpret or to criticise philosophers of the past, in any direct sense. I remember, still with a feeling of vicarious embarrassment, a talk on Plato's *Phaedo* by a new-comer to a Cambridge chair, who drew flattering titters from an undergraduate audience by listing the deficiencies that he, as a modern philosopher, saw in Plato's conception of form and of the self. This is not the kind of

interpretation that I would aim at, although I can see the advantage of treating Plato and Aristotle as philosophers in their own right, whose interests still to some extent coincide with our own.¹

At the same time, I find it frustrating to treat the history of ideas as episodically as one might treat the history of events. Democritus' ideas are not, I think, appreciated, if he is seen as simply one member of a succession of early philosophers, nor if his ideas are seen as a 'brilliant anticipation' (Gomperz's phrase) of the supposed discoveries of modern science.² To use a rather foolishly quantitative form of expression: the history of ideas seems to me to be more than history, and less than philosophy, or less than science in a modern sense.

But perhaps I have dug my own grave. I am more conscious of the need for some element of interpretation, than I am confident of my own ability to provide it. No doubt there are other and better ways of applying the human mind to understanding the history of ideas. The course I have adopted is simply to try to present these three theories of weight as typifying, on however minuscule a scale, the development as well as the mere succession of ideas. There is a sense, it seems to me, in which Aristotle's conception of weight is indeed present implicitly in the earlier Democritean conception, and equally a sense in which Democritus' conception lingers in Aristotle, while Plato holds the two ideas in suspension, as it were, the new and the old skilfully held in opposition by the particular conception that Plato has of the relation between reason and necessity, and between perception and reality.

This finally is the reason for the particular attention that I have given in my study to the influence of Aristotle. If a later idea can properly be described as implicit in some earlier conception, then clearly once the idea has been made explicit there is the danger that it will seem to loom larger in its initial appearance, and then the further danger that in retrospect it will thereby come to oust

¹ Cf. P. Wilpert, *Festschrift für Aloys Wenzl* (München-Pasing, 1950) 57: '... auch die ganz Grossen ihre kleinen Fussangeln haben, über die sie stolpern. Dem pietätlosen Spätgeborenen ist es ein billiges Vergnügen darüber zu lächeln, wenn auch bei ihm vielleicht schon der Sohn die dicken Taue sieht, über die der Vater gestrauchelt'.

² T. Gomperz, *Griechische Denker, eine Geschichte der antiken Philosophie* 4th edn i (1922) 305.

the conceptions with which it was initially associated, and to which it was originally subordinated. The kind of evidence that I have had to consider in these essays therefore tends to obliterate precisely those features that are most necessary for a successful reconstruction of the development of ideas: for the evidence tends to obliterate precisely those features which are least familiar to the later historians of antiquity, and to ourselves.

Reconstruction and interpretation, at least of the kind that I have offered here, are therefore less separable than might at first appear. In either case, it is the dominating influence of later ideas which disrupts our reconstruction of the evidence, and which keeps us from a proper analysis of the development of ideas, as a process which is at once more than the simple sequence of ideas as events, and yet which is independent of whether we ourselves suppose the ideas in question to be true or false.

ABBREVIATIONS

Any references to modern works that are not immediately clear may be recovered from the BIBLIOGRAPHY. In general, I have given a full reference the first time a work is referred to, and thereafter I have used the author's name with an abbreviated form of title. The shortest and the most common of these abbreviations are:

Burnet <i>EGP</i>	J. Burnet, <i>Early Greek philosophy</i> , 1st edn 1892, 4th edn (a reprint of the 3rd edn) 1930.
Cherniss <i>ACP</i>	H. Cherniss, <i>Aristotle's criticism of Presocratic philosophy</i> , 1935.
Cherniss <i>ACPI</i>	H. Cherniss, <i>Aristotle's criticism of Plato and the Academy</i> , 1944.
Cornford, <i>Cosmology</i>	F.M. Cornford, <i>Plato's cosmology, the 'Timaeus' of Plato translated with running commentary</i> , 1937.
Diels, <i>Dox.</i>	H. Diels, <i>Doxographi graeci</i> , 1879.
Guthrie, <i>History</i>	W.K.C. Guthrie, <i>A history of Greek philosophy</i> , currently appearing in several volumes, vol. i 1962.
Taylor, <i>Commentary</i>	A.E. Taylor, <i>A commentary on Plato's 'Timaeus'</i> , 1928.
Zeller, <i>ZN</i>	E. Zeller, <i>Die Philosophie der Griechen in ihrer geschichtlichen Entwicklung</i> , 1st edn 1844, 6th edn of Teil i Hälfte 1–2 by W. Nestle 1919–20.

Two other works are commonly referred to in an abbreviated form:

DK	H. Diels, <i>Fragmente der Vorsokratiker</i> , 1st edn 1903: the pagination is unchanged from the 5th edn by W. Kranz, 1934–7.
LSJ	<i>A Greek-English Lexicon</i> by Liddell, Scott and Jones, 9th edn 1940.

References to periodicals are given in an abbreviated form in the footnotes, and in a full form in the BIBLIOGRAPHY.

The INDEX LOCORUM specifies the editions used of ancient texts. After the first full reference, I have used the author's or editor's name alone for some critical works on, and for some editions or translations of, Plato's *Timaeus*, Aristotle *De caelo* and Theophrastus *De sensibus*.

**PART ONE—
PRIMARY EVIDENCE**

Chapter One— Aristotle's General Criticism of the Atomic Theory

§ 1— Orientation

(i)

A large number of writings were attributed to Democritus in the ancient world, but among the fragments that survive there is no mention of weight.

Initially, we have to make do therefore with information that can be recovered from those who had read the works of Democritus, or of his immediate associate Leucippus, and who transcribe, and criticise, their theories. Chief among these are Aristotle, and his pupil and successor as head of the Lyceum, Theophrastus. Both Aristotle and Theophrastus had clearly read the whole, or a large part, of the works of Democritus, and both refer, in some detail, to the atomic theory of weight.¹

But even the works of Aristotle and of Theophrastus do not survive in their entirety. In particular, a monograph which Aristotle devoted to Democritus has been lost, except for a single extract transcribed by Simplicius. Theophrastus' detailed accounts of the Presocratics, including his history *The opinions of the physical philosophers*, have been mostly lost. The longest continuous portion which survives of such writing. *On the nature of the senses and on the objects of sensation*, does contain an account of the atomic theory of weight. But the fragments quoted from Theophrastus by Simplicius, concerning earlier opinions on the first principles of physical philosophy, do not mention this feature of the atomic theory.

¹ Diogenes Laertius lists seventy titles in his *Life* of Democritus, ix 46–9 (DK 68A1). A useful list of references to these and other works that, rightly or wrongly, were attributed to Democritus in antiquity is provided by Louis Liard, *De Democrito philosopho* (Paris, 1873) 15–25, and by Léopold Mabillean, *Histoire de la philosophie atomistique* (Paris, 1895) 152–67. Mabillean adds, 167–71, an instructive schema of passages in Aristotle on ancient Atomism.

Ancient authors who in one way or another depend on works of Aristotle and of Theophrastus that are lost to us therefore represent a second stratum of potential information on the theories of the Atomists: chief among these, on the question of weight, are Simplicius, Aetius and Cicero.¹

(ii)

In these conditions, it seems to me impossible to attempt any distinction on this question between the theories of the two atomist philosophers of the fifth century, Leucippus and Democritus.

Cyril Bailey (whose account of Atomism in the fifth century, although it has all the appearance of a careful and judicious survey, is in fact far inferior to his analysis of the later version of Atomism adopted by Epicurus) appears to suppose that Democritus introduced weight into the simpler atomic theory of Leucip-

¹ The most recent research on Theophrastus' doxographical writings concludes that the *Physicorum opiniones* was put together from a series of monographs on individual philosophers, and was in turn re-written to form part of Theophrastus' own analyses of physical philosophy. On this interpretation, the long fragment *De sensibus* and the quotations preserved by Simplicius are derived not from the original *Physicorum opiniones*, as Diels had supposed, but from a later re-handling of the same material. See Peter Steinmetz, *Die Physik des Theophrastos von Eresos*, in the series *Palingenesia* Band i (Bad Homburg V.D.H., 1964) esp. pp.334–51 *Beilage* 'Theophrasts Physik und ihr Verhältnis zu den Φυσικῶν δόξαι'.

Although the nature of Theophrastus' doxographical writing undoubtedly requires much more intensive study than it has so far received, it seems to me that the conclusion which Steinmetz reaches turns on a very tenuous distinction: the claim, in effect, to distinguish between two, if not three, different versions, or different uses, of the *Physicorum opiniones*—as a series of monographs, as a single work, and as a preliminary to Theophrastus' own philosophy.

In particular, Steinmetz's treatment of the *De sensibus* has, I think, been rightly criticised by O. Gigon, who repeats the view, which had been held by Diels and others, that this fragment is part of the original *Physicorum opiniones*. 'Die ἀρχαὶ der Vorsokratiker bei Theophrast und Aristoteles', *Symposium Aristotelicum* 4 (Heidelberg, 1969) 117. Unfortunately, Gigon's own thesis, that the *Physicorum opiniones* was prior to, and was used by Aristotle for, the doxographical accounts that preface the *Physics* and the *Metaphysics*, seems to me very questionable, as apparently it did also to some of those who were present at the *Symposium*, see I. Düring's 'Zur Einführung' 13.

Throughout this present study, I have adopted a generally traditional view of the relation between Aristotle, Theophrastus and the *Placita*, while trying to leave open the possibilities for correction by future research on points of detail: cf. especially pp.281 and 299–302 below.

pus, as part of the idea that Democritus 'makes far greater use than Leucippus of differences in size'.¹

But Bailey is misled by his uncritical acceptance of evidence that Democritus believed that the atoms were 'infinite in size', and that there could be 'an atom as big as a cosmos'. Both pieces of evidence run directly counter to Aristotle's assertion that the atoms were too small to be perceived. The origin of the error can with fair certainty be traced to a confused application of principles which Epicurus introduced into the earlier atomic system, in order to counter criticisms that Aristotle had made of the original form of the theory, and which by a common doxographical failing were then read back into the original theory.²

Once we have discounted these two pieces of evidence, any impression that Democritus made 'far greater use' of size than did Leucippus arises solely from the fact that there is ten times more evidence for Democritus, or for Democritus and Leucippus together, than there is for Leucippus on his own.

I doubt myself that any useful distinction can be drawn between Democritus and Leucippus on the question of size, and still less on the question of weight. If any such distinction were to be attempted, it would in any case have to be subsequent to an analysis of the evidence contained in the present essay.

(iii)

I turn therefore directly to the question which is the subject of my study: whether, or in what sense, the atoms of Democritus, or of Democritus and Leucippus, had weight.

Two passages in Aristotle are directly relevant to this question, from the *De caelo* and from the *De generatione et corruptione*. The interpretation of these two passages has been much disputed, and I do not believe that either passage has been properly understood

¹ *The Greek Atomists and Epicurus* (Oxford, 1928) 125–9, cf. 144. A more limited move in the same direction is made by Adolf Dyroff, *Demokritstudien* (Leipzig, 1899) 32.

Bailey's work on fifth-century Atomism followed shortly after his *Epicurus, the extant remains, with short critical apparatus, translation and notes* (Oxford, 1926).

² For evidence and argument see below ch.X § 4, pp.282–98.

hitherto. In the two chapters which follow (chapters II and III) I shall therefore consider these two passages in detail.¹

We need first, however, to consider one broader problem. This is the general criticism which Aristotle makes of the atomic theory of weight in the *De caelo*, and especially in the fourth book, where Aristotle expounds at length his own theory of absolute and of relative weight.

In these more general passages of criticism, Aristotle deals with the atomic theory in terms of a simple opposition between void and plenum, as opposed primarily to the theory of the *Timaeus*, which in the fourth book of the *De caelo* Aristotle chooses for the most part to regard as founded on the denial of void and the assertion of triangles or surfaces as opposed to solid or plenum. Some understanding of the way in which Aristotle views the atomic theory in these more general passages of criticism is essential to a solution of the problems which confront us in the two passages where Aristotle deals specifically with the weight of individual atoms, in the *De caelo* and in the *De generatione et corruptione*.

The remainder of this chapter is therefore devoted to a preliminary study of Aristotle's general criticisms of the atomic theory, in the *De caelo* and especially in book four, by way of providing the necessary context for a more detailed study of the two passages where Aristotle, or so I shall argue, writes specifically of the weight of atoms.

§ 2—

The Distinction of Relative and Absolute Weight

In its simplest form, Aristotle's theory of relative and absolute weight is that fire is light absolutely because it moves always upwards, and does so more quickly, and is therefore lighter, in the larger quantity; and that earth is heavy absolutely because it moves always downwards, and does so more quickly, and is therefore heavier, in the larger quantity; while air and water are each of them relatively light and relatively heavy because they move

¹ The two passages are *De gen. et corr.* i 8, 325b36–326a14 (in part DK 68A60), see ch.II, pp.41–79 below; and *De caelo* iv 2, 308b28–309a11 (in part DK 68A60), see ch.III, pp.80–114 below.

upwards in the region of earth and downwards in the region of fire.¹

It is a common belief, exemplified notably by Professor Cherniss, that Aristotle views the atomic theory within the context of his own belief, in such a way that the atoms cannot be regarded as heavy absolutely, and must therefore be seen by Aristotle as possessing only relative weight.²

The truth, I believe, is just the opposite of this. I shall argue that Aristotle sees the atoms themselves as possessing, or as approximating to the possession of, absolute weight, and that it is only the bodies formed from the atoms which Aristotle regards as limited to the possession of relative weight.

'De Caelo' Book Four

(i)

Cherniss has been led to his conclusion in part by a passage from the opening of book four of the *De caelo*, where Aristotle writes that his predecessors had not spoken of absolute weight, iv τὸ κοῦφον, ἀλλὰ τί τὸ βαρύτερον καὶ κουφό-τερον ἐν τοῖς ἔχουσι βάρος.

¹ Nothing has been said by people in the past on the subject of elements with absolute weight, but only on the question of bodies <which are heavier or lighter> in relation to something else.

² For our predecessors do not say what it is that is heavy <in itself> and what it is that is light <in itself>, but only what it is among things that have heaviness that is heavier and <what it is> that is lighter.³

¹ This summarises especially *De caelo* iv 4, 311a15–29.

² Harold Cherniss, *Aristotle's criticism of Presocratic philosophy* (henceforward *ACP*) (Baltimore, 1935) 97–9, esp. 97 n.412, and 209–13. For a fuller statement of Cherniss' position, see below pp.46ff.

³ For the nature of these English versions—paraphrases and not translations—see the warning at the head of the Index Locorum.

According to Cherniss, this passage 'shows that Aristotle did not mean to say that Democritus attributed absolute weight to the atoms'.¹

(ii)

However, the scope of Aristotle's remark is qualified a few lines later, when the same sentiments are attributed only to a 'majority', iv 2, 308a34–b3: αὐτοῖς οὐκ ἐφαρμόττει.

'The majority, generally speaking, of those who earlier have applied themselves to the subject of our enquiry have limited their remarks on bodies that are heavy and light to bodies that are so in the sense only that when two bodies both have heaviness one of them is lighter than the other.

'By proceeding in this way, they think that they have given a definition which includes what is light and what is heavy in an absolute sense: but their argument fails to match <their conception of it>.'

The restriction in σχεδὸν οἱ πλεῖστοι Cherniss obliterates by paraphrasing both passages together as Aristotle's complaint that: '*no one* of his predecessors . . . had considered the question of absolute weight' (my italics).²

¹ ACP 97 n.412. A similar point is made by Dyroff, *Demokritstudien* 37, John Burnet, *Early Greek philosophy* 3rd edn (London, 1920) (henceforward *EGP*) 343, and Bailey, *Greek Atomists* 129–33 and 144–5.

² ACP 210: that both passages are intended is shown by the references in n.250.

A peculiarity of English makes it impossible to translate σχεδὸν.

One might well be puzzled by the rather curious formulation which Aristotle employs at this point: his predecessors have spoken only of bodies 'which both have heaviness, and of which one is lighter than the other'. The reason for both

(footnote continued on next page)

(iii)

But Aristotle's restriction is not an empty formality, at least not with regard to what is heavy absolutely. For later in his critique of earlier thinkers Aristotle writes of there being 'certain others', apart from himself, 'who agree that there is something heavy absolutely', iv 4, 311b14–19:

ἐτέροις, καὶ αὖτις φέρεσθαι πρὸς τὸ μέσον. ἔστι δ' ὁμοίως καὶ τὸ κοῦφον.

'By "light absolutely" I mean a body which is so constituted by nature as to travel consistently upwards, provided that it is free from any impediment, and by "heavy" <absolutely> a body which <in the same way> travels consistently downwards.

'For bodies of <both> these kinds do exist, and it is not the case, as some people suppose, that all bodies have heaviness. For certain others agree that there does exist <a body which is> heavy, and which travels consistently towards the centre.

'The point <which they fail to see> is that in just the same way there does also exist a body which is light <absolutely>.'

(footnote continued from previous page)

bodies having heaviness, here and in Aristotle's earlier generalisation, is that while people have recognised the existence of bodies with heaviness they have failed to recognise the existence of a body that has lightness or that is light absolutely, as we learn in the passage which I quote immediately after this, iv 4, 311b14–19. But why, in this second generalisation, does Aristotle single out one body as being lighter?

The answer, I suspect, lies in the definition immediately preceding of relative lightness as determined by differences in speed of movement, iv 1, 308a31–3. This definition has been a constant source of difficulty; I shall give some time to the analysis of it in my third essay. In its simplest terms, the reason for this present formulation I take to be that two portions of earth would both have heaviness, while the larger would be the heavier of the two: both portions however would be heavy absolutely. On the other hand, if one body is lighter than the other, then it cannot be heavy absolutely, while equally, since it has been defined as 'having heaviness', it cannot be light absolutely. Thus Aristotle's formulation is designed to specify a form of comparison which must introduce an element which even according to the criteria of his own system cannot have absolute weight.

Cherniss identifies the 'certain others' who 'agree that there is something absolutely heavy' as Plato and 'probably' the Atomists.¹ But as it stands this is inconsistent with his earlier assertion that 'Aristotle did *not* mean to say that Democritus attributed absolute weight to the atoms' (my italics).²

Cherniss is not alone in this inconsistency. Moraux paraphrases Aristotle's first passage (iv 1, 308a9–13) as meaning that: 'Personne ne paraît avoir soupçonné l'existence d'un lourd absolu'. But in this present passage he tells us that: 'L'existence du lourd . . . personne ne met en doute', where in the context he must still mean 'le lourd absolu'.³

The truth is that in the light of Aristotle's later critique we cannot assume, as Cherniss and Moraux have done, that *no one* of Aristotle's predecessors can have introduced an entity that Aristotle would have recognised as having absolute weight, nor more particularly therefore that the atoms cannot have been accounted by Aristotle as being heavy absolutely.

As it is, if we examine the criticisms which Aristotle makes of the Atomists, in the course of the *De caelo*, we discover that in

¹ *ACP* 209 n.247.

² *ACP* 97 n.412, cf. 210.

³ P. Moraux, 'Recherches sur le *De caelo* d'Aristote, objet et structure de l'ouvrage', *Revue thomiste* année 59 tome 51 (1951) 190 and 191.

I hope that it is not unfair to single out Moraux's earlier article. In the account of the later passage in the Introduction to Moraux's Budé edition of the *De caelo* (Paris, 1965), there does seem to be a distinction between 'le lourd' and 'le lourd absolu' (clvi). However, in the Budé edition there is, I think, an error of another kind. The later passage (iv 4, 311b14–19) Moraux translates, 147, '... d'autres aussi l'admettent', and adds 147 n.2, 'et non pas uniquement ceux qui croient que tout est pesant'. The same sense is given, the other way round, in Tricot's translation (Paris, 1949) 170: 'En fait, ces philosophes', those last mentioned, 'sont d'accord avec d'autres . . . '.

But if there are two different groups which nonetheless both believe in the existence of a body which has absolute heaviness, then it is difficult to see what distinguishes them, unless it is that the second group does suppose that some things are light, which would spoil the point of Aristotle's correction: ἔστι δ' ὁμοίως καὶ τὸ κοῦρον.

It seems to me much more natural to take καὶ ἑτέροις then most naturally means for these others as also for Aristotle: 'some think that all things have only heaviness, for certain others do indeed think, as we do . . .'. This is the sense given by Guthrie, Loeb edn (London, 1939) 355: 'Others besides ourselves agree . . . '.

Aristotle's estimation the atoms themselves do in fact have, or at least approximate to having, absolute weight.¹

'De Caelo' Book One

(i)

The general orientation of Aristotle's criticism of Democritus is perhaps most clearly indicated in a passage from the first book of the *De caelo*, where Aristotle argues that the atoms have a single εἰ πάντ' ἔχει βάρος· εἰ δὲ κούφότηα, βαρὺ οὐδέν.

'If the whole is not continuous, if on the contrary, as Democritus and Leucippus claim, <the whole is in effect> parts divided up by void, there will have to be a single movement for all things.

'For <on their theory> all things <i.e. all the parts of the universe, in effect all the atoms> are distinguished <only> by their shapes, whereas their nature is one <and the same>, or so they claim, just as if each <part or piece of the universe> were <a piece of gold—> gold which is split up into pieces.

¹ I shall argue later that Aristotle's criticisms are to be read in the light of a distinction between the atoms themselves and bodies formed from the atoms: Aristotle allows that the atoms themselves have absolute weight, but denies that there can be any distinction between absolute and relative weight in bodies that are formed from the atoms. I have nonetheless accused Cherniss and Moraux of inconsistency, since neither shows any awareness of this ambiguity in Aristotle's classification of the Atomists: certainly in Cherniss, the contradiction is fairly plainly the result of sheer inadvertence. For my own interpretation see especially § 5, pp.32–40 below; the way in which Plato, as I believe, is included in Aristotle's present criticism will be analysed in my second and third essays.

'I repeat, the movement of such parts <or pieces, having as they do all the same nature, as separate pieces of gold would do> has to be <one and> the same.

'<This follows from a comparison with the behaviour of earth and fire.> Take a single lump of earth: wherever that travels to <if you let it fall, so that it follows its natural motion>, that is where earth as a whole travels to; and in just the same way a single spark of fire and fire as a whole travel to their <proper> place <which is one and> the same <for a part and for the whole>. <So too therefore, for Democritus and Leucippus, the atoms, if they are to have all the same nature, like separate pieces of gold, will have to have movement all in the one direction.>

'Observe the conclusion: if everything has *heaviness* <—and remember that on this theory everything has the same nature, and can have only one nature; it can be only one kind of thing—>, then none of the bodies <in the universe> can be <of a different kind, so that none of them can be> *light* absolutely.

'<The argument works the other way round,> if <you suppose that> everything has *lightness* <and not heaviness, the only difference then is that in that case there can be> nothing <that is different in kind, and so that could be> *heavy* <absolutely>.'

The point of this criticism is that if the atoms have all a single nature, then they must have movement all in the same direction. There are therefore two possibilities.

1. The atoms move downwards, and are therefore all heavy (κοῦφον ἀπλῶς οὐθὲν ἔσ-ται τῶν σωμάτων).
2. Alternatively, the atoms move upwards, and are therefore all light (βαρὺ οὐδὲν sc. ἀπλῶς ἔσται τῶν σωμάτων).

From this, the natural implication is that the atoms are in fact reckoned by Aristotle *either* as heavy absolutely *or* as light absolutely, but *not* therefore as having relative weight.¹

(ii)

A similar point is made by Theophrastus, in his criticism of Democritus' theory of weight. This passage I shall study later, in my examination of Theophrastus' account of Democritus.

The precise form of Theophrastus' criticism differs from that of Aristotle on a couple of points of detail. But the burden is again that for Democritus material bodies have a single nature and movement all in the same direction. The obvious conclusion—the unspoken criticism—is again therefore that there cannot be any radical distinction of heavy and light in Democritus' universe, of the kind that both Theophrastus and Aristotle believe to be an observable and demonstrable feature of the visible cosmos.²

(iii)

Liepmann takes Theophrastus to be in agreement with Aristotle, and writes of his argument:

'Wenn die Schwere proportional mit der Masse wächst, dann kann es kein absolut Leichtes, oder *absolut* Schweres geben, sondern Alles wird *relativ* schwer . . .'³

¹ For the transition in Aristotle's argument between atoms and the four cosmic elements see below pp.139–41.

In my summary of Aristotle's argument, in the two numbered paragraphs, I insert 'absolutely' only where Aristotle does, either explicitly, as in the conclusion of his *first* argument, that there will be nothing that is light absolutely, or by obvious and inevitable implication, as in the conclusion to the *second* arm of his argument, the conclusion that there will be nothing that is heavy *sc.* absolutely.

I have not added this qualification to the premiss of either argument, 'if everything is heavy', 'if everything is light': the point of my argument is that the qualification is not there stated explicitly, but that its presence is implied. The criticism I take to be constructed in such a way that the *premiss* of either argument is formed from the *conclusion* to the alternative argument.

² *De sens.* 71 (DK 68A135): see below ch.IV §§ 2–3, pp.132–50.

³ Hugo C. Liepmann, *Die Mechanik der Leucipp-Democritischen Atome, unter besonderer Berücksichtigung der Frage nach dem Ursprung der Bewegung derselben* (Berlin, 1885; Leipzig 1886) (henceforward *Mechanik*) 41.

This gets hold of the wrong end of the stick altogether. The argument—whether in Aristotle or in Theophrastus—is not that the atoms are *neither* absolutely heavy *nor* absolutely light. Aristotle's point is that if they are the one they cannot be the other. From this, there is no reason to conclude that the atoms have relative weight.

On the contrary, the natural implication, it seems to me, if we take the two passages together, that in Theophrastus and that in Aristotle, will again be that on Aristotelean principles the atoms are in fact reckoned *either* as heavy absolutely *or* as light absolutely, but *not* therefore as having relative weight.¹

Conclusion

(i)

Cherniss believes that Democritus' atoms cannot be reckoned by Aristotle as heavy absolutely, and that they must therefore be treated by him as having weight in only a relative sense.

But Cherniss fails to take account of the qualifications which Aristotle introduces into the generalisations which he provides of the ideas of weight in earlier philosophy. Aristotle tells us that it is only a 'majority' of earlier philosophers which ignores the existence of elements with absolute weight. 'Certain others', accord-

¹ For the distinction between the atoms and the four cosmic elements in Theophrastus' criticism see below pp.133ff. and 139ff. It might be objected that Aristotle's argument is simply that if the atoms have heaviness *at all* they cannot be light *absolutely*, since what is light absolutely, in Aristotle's own theory, cannot be in any sense heavy or heavier (cf. iv 4, 311b26–9): and that premiss and conclusion do not therefore correspond.

But note that in the parallel argument, from the end of book four, the same expression is used for both the premiss and the conclusion of the argument: if there exists only what moves *always upwards* εἰ δὲ κουφώτητα, βαρὺ οὐδέν, cap. 7, 276a5–6, p.11 above) would seem to imply that in both premiss and conclusion the atoms are thought of as having absolute weight, in the passage from book one as in the passage from book four.

More specifically it may be objected that the premiss in the argument from book one includes both relative and absolute weight: the atoms, it might be said, move downwards with differences of speed, and some of them are relatively heavy therefore, while others are heavy absolutely.

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ing to Aristotle, do in fact 'agree' that there exists a body which is heavy absolutely. We cannot *a priori* exclude the Atomists from this latter classification.

(ii)

In fact, in the first book of the *De caelo* Aristotle does treat the atoms as approximating to the possession of absolute weight, since the atoms are treated as having movement always in the same direction. The natural implication of Aristotle's argument—repeated, from a slightly different point of view, by Theophrastus—is that if the atoms are heavy absolutely, then there can be nothing that is light absolutely, and *vice versa*. The lesson of this would seem to be that in Aristotle's estimation the atoms do in fact have one form or other of absolute weight. They are either heavy absolutely or light absolutely. Aristotle's point—so far—is that they cannot be both at once.

§ 3—

Classification of the Weight of Atoms: Approximation to Absolute Weight

Aristotle's critique of the atomic theory of weight in book four of the *De caelo* follows consistently from the passage which I have

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But for this conclusion to follow, we should have to argue that atoms of *equal* size moved downwards with differences of speed: only so would there be a difference between relative and absolute weight (*cf.* the definition of relative lightness at *De caelo* iv 1, 308a31–3, which I have already alluded to, and which I shall analyse fully in my third essay). This would, I think, be a difficult and implausible condition to impose at this point, and it is also, I think, excluded both by the general principle and by the particular example: the atoms have all the same nature, and they move all in the same direction therefore, as do different quantities of fire or of earth. There is here no obvious question of differences of speed; and, even if differences of speed were here in question, the same quantity of fire or of earth would travel upwards, or downwards, with the same speed; for if two quantities of fire or of earth of the same size travelled upwards, or downwards, with *differences* of speed, then their nature would no longer be 'one' and their movement would no longer be 'the same'.

I have nonetheless, in deference to the very simple form of Aristotle's argument, claimed only that the atoms' possession of absolute weight—heaviness or lightness—is a 'natural' implication, although in fact, if we pursue the consequences of his analysis, it is, I think, the only implication possible.

quoted from the first book, where the atoms are reckoned as having a single 'nature' and a single 'movement'.

'Earth and Fire'

(i)

Aristotle's first detailed argument against the Atomists is again presented in the form of an alternative.

1. If weight is determined by the amount of solid, then a tiny quantity of earth will have less solid than a large quantity of fire, and fire will be heavier than earth.
2. If weight is determined by the amount of void, then a large quantity of earth will have more void than a tiny quantity of fire, and earth will be lighter than fire.

In this way, fire and earth, which should have absolute weight, prove not to do so, since either fire will fall below earth, on the *first* argument, or earth will rise above fire, on the *second* argument. The consequence of the *first* argument is that earth cannot be (as it is in Aristotle's own philosophy) heavy absolutely. The consequence of the *second* argument is that fire cannot be (as it is in Aristotle's own philosophy) light absolutely.¹

(ii)

Of this argument, or pair of arguments, Cherniss writes that it is clear that Aristotle 'would have maintained the necessity of

¹ *De caelo* iv 2, 309a33–b4. The passage is quoted and paraphrased below pp.108–9. The more precise genesis of this argument, and the expression of it, are however somewhat complex, and I therefore reserve a full analysis for the earlier of my two essays on Aristotle.

It might be objected that logically the conclusion of the argument, as I have stated it, does not exclude fire being heavy absolutely and earth being light absolutely, and that elements with absolute weight do therefore have a place in the atomic system. But this objection would lead only to the same argument, and an infinite regress. As it is, Aristotle is content with the double absurdity, that there is something lighter than what is light absolutely, and that 'what always <and only> moves downwards will be lighter than what always <and only> moves upwards' (309b3–4).

attributing weight to the atoms if the complex bodies were to have weight'. But, he continues, Aristotle's objection 'is just that the Atomists did not call the complex bodies *absolutely* heavy or light which in itself implies that they did not attribute real weight to the atoms'.¹

In writing this, Cherniss plainly does not appreciate the force of the distinction between atoms and bodies formed from the atoms. In the argument which I have summarised, Aristotle does complain that any body formed from the atoms and purporting to possess absolute weight can be shown not to do so. But Aristotle does not say, nor does his criticism require or imply, that the atoms themselves do not have 'real' weight.

On the contrary, Aristotle's form of criticism requires that the atoms themselves do approximate to the possession of what Aristotle would call absolute weight. For Aristotle's *first* argument turns on the idea that if heaviness is determined by the amount of atomic solid then both bodies will always move downwards, while the body with more atomic solid will be heavier than the body with less atomic solid, whichever of the four cosmic elements it may be supposed to constitute or to represent, just as on Aristotle's own theory a body with absolute heaviness will always move downwards, while a larger portion of such a body will be heavier than a smaller portion.

The point which underlies Aristotle's criticism is that on the atomic theory the distinction between earth and fire cannot be a

¹ *ACP* 211 n.253. It is possible that I am doing Cherniss an injustice here. He writes in fact: it is 'clear *from the following argument . . .*' (my italics). Which argument this is meant to be is not wholly clear, to me, from the sequence of Cherniss' remarks. In the context, the 'following' argument would seem to refer to the contrast between Plato's surfaces and the Atomists' solids (iv 2, 308b35–309a2). But the content of Aristotle's 'objection' seems to be taken from the argument which I have quoted, and from the similar arguments which follow.

At this point therefore I take Cherniss' remark to relate to the argument which I have just summarised. Later, pp.102–3 and 112–14 below, I shall take the first part of his remark to cover the contrast between Plato and the Atomists on surfaces and solids. One or the other argument, I hope, will answer to Cherniss' intention.

The doxographical evidence from Aetius which Cherniss introduces at this point I am reserving for separate consideration later, ch.VIII §§ 1–2, pp.223–39 below. The passage which Cherniss cites from Simplicius, *De caelo* 295.5–20 (= Arist. fr. 208 Rose), does not contain any explicit mention of weight, see below ch.XI, pp.303–29.

distinction of kind. Earth and fire are essentially the same, in so far as they are made of the same material, the atoms, and Aristotle therefore supposes that they must have movement in the same direction. If this movement is determined by the amount of solid, it will be movement downwards. If it is determined by the amount of void, it will be movement upwards. In either case, the body with more solid or with more void will be heavier or lighter than the other, irrespective of whether or not it be taken to represent earth or to represent fire.

Thus the attempt to construct a body with absolute weight from the atoms fails. But this is only because the atoms *themselves* are envisaged as approximating to the possession of absolute heaviness. The argument is that the body which is initially supposed to represent earth, and so to be heavy absolutely, can be shown to be in fact less heavy than a body which is supposed to represent fire, and so to be light absolutely, but which, in a certain quantity, will have more atoms, or more 'solid', and will therefore in fact be heavier.

(iii)

The basis of Aristotle's criticism is therefore essentially the same as that of the criticism which I quoted earlier from the first book of the *De caelo*, with the difference that in this later argument Aristotle makes allowance for the presence of void.

1. In the earlier argument, the atoms are envisaged as moving *either* upwards *or* downwards.
2. In the present argument, the atoms are envisaged as moving only downwards, and void is introduced to allow for the possibility of upward movement.

However, in the present argument the Atomists are allowed only one of these possibilities: *either* a body moves downwards because it has more solid, *or* it moves upwards because it has more void. The structure and the assumption of either argument therefore remain essentially similar.

1. In the earlier argument, from the first book of the *De caelo*, *either* the atoms are all heavy absolutely, in which case

there can be nothing that is light absolutely, *or else* the atoms are all light absolutely, in which case there can be nothing that is heavy absolutely.

2. In the present argument, from the fourth book, the atoms cannot be reckoned as constituting a body which is heavy absolutely, since at the same time they would have to constitute a body that is light absolutely: but a large quantity of the latter body would contain more atomic solid than a small quantity of the body which purported to be heavy absolutely, and the body which was light absolutely would therefore turn out to be heavier, in a certain quantity, than the body which purported to be heavy absolutely.

Thus in both arguments the assumption is essentially the same: that the atoms themselves represent, or approximate to, the possession of absolute weight, in that the atoms can have movement in only a single direction; while if, as in the version I have given of the argument from book four, absolute weight is specified as absolute heaviness, then the body with a larger quantity of atomic solid will be heavier than a body with less.¹

¹ I have simplified the argument in book four by pursuing only the 'active' member of the definition for a body that is heavy absolutely. The full form of Aristotle's argument implies two pairs of definitions: (1) a body is heavy absolutely *either* because it has more solid *or* because it has less void; (2) a body is light absolutely *either* because it has more void *or* because it has less solid. But in practice Aristotle employs only the *first* member of the *first* definition to determine whether a body is heavy absolutely, and only the *first* member of the *second* definition to determine whether a body is light absolutely. The reason for the elaboration, and for the restriction, I attempt to establish in my analysis of Aristotle's theory.

The essential feature of this form of Aristotle's argument is that so far he does not consider atoms and the void as *jointly* determining the weight of a body. His argument is cast in the form of an alternative: *either* weight is determined by the amount of solid, *or* it is determined by the amount of void (309a33–4). This may seem to trivialise Aristotle's argument, or it may seem unfair to the Atomists. I shall argue nonetheless, in the analysis of the *De caelo* in my third essay, that this disjunction is a crucial element in the whole of Aristotle's critique of the atomist theory, and that Aristotle's difficulties in criticising the atomist theory spring ultimately from the fact that if he takes atoms and void as jointly determining the weight of a body then he comes close to recognising that a *single* opposition, heavy/light, cannot easily generate the distinction between *four* ultimate and irreducible (although transformable) elements, as it is required to do in his own theory.

'Earth and Air'

So far, Aristotle has argued that the atomic theory cannot provide for two elements with absolute weight. In a later argument in the fourth book of the *De caelo*, directed jointly against the Atomists and against Plato, Aristotle argues that neither the atomist nor the Platonic theory can provide for the combination of an element with absolute weight and an element with relative weight.

(i)

This latest argument is especially interesting, for it begins virtually by re-stating the argument which I quoted earlier from the first book of the *De caelo*. This now appears in the following form, iv 5, 312b19–28: *ἐὰν δὲ τὸ κενὸν ἢ τι τοιοῦτον ὁ ἀεὶ ἄνω, οὐκ ἔσται ὁ ἀεὶ κάτω*.

'It is essential for there to be as many differences <of movement towards a natural place> as there are elements in the cosmos.

'This will be plain from the following argument.

'If there is a single material principle for all things, whether it be void or plenum or extended magnitude or triangles, then *either* everything will move upwards *or* everything will move downwards. In *either* case, there will no longer be any <natural> movement in the opposite direction.

'Consequently, *either* there will be nothing which is light absolutely, if everything tends to move downwards more <quickly or to sink further> in so far as it is made from larger bodies or from a greater number of bodies or from bodies that have no void . . . <*or alternatively*> if everything is made of void or of something else which is of a kind to move always upwards, then there will be nothing which will move always downwards.'

(ii)

Aristotle now extends this argument to include intermediate elements, 312b28–32: τοῦ κούφου, εἰάν ἐκεῖνο ποιῇ τις ὑπερ-ἔχειν τῇ ὕλῃ.

'<It follows> also <from any one of these theories> that some <quantities> of the intermediate elements <namely air and water> will be carried downwards more quickly than earth.

'Thus in a large quantity of air there will be more triangles or <more> solid particles or <more> tiny particles <than in a small quantity of earth>.

'<From this it should follow that the larger quantity of air is carried downwards more swiftly than the small quantity of earth:> but we never do see any quantity at all of air carried downwards <more quickly than earth>.

'The equivalent argument follows if we consider the question of lightness, and if one arranges for there to be more of what is light by way of the material principle <in one or other element>.

'<For in that case a large quantity of water would have more of the material principle of lightness, say more void, than a small quantity of fire has, and the water should therefore be carried upwards more quickly. But we never do see any quantity at all of water carried upwards more quickly than fire.>'

There are some difficulties of interpretation here. If we adopt the conclusion which I shall argue for later, in an analysis of the fourth book of the *De caelo* taken as a whole, then Aristotle's purpose, in the first of this pair of arguments, is again to show that if air and earth are alike made from the atoms, then any portion of either element with a larger quantity of atomic solid will be carried downwards more swiftly than any portion with a smaller quantity of atomic solid. But a larger portion of air can have more atomic solid than a small portion of earth. Conse-

quently, air would have to be carried downwards, in a certain quantity, more swiftly than earth: and that Aristotle holds to be impossible.

As before, Aristotle is in effect treating the atoms as approximating to the possession of absolute weight, in that the atoms are envisaged as having a single movement downwards, while the larger quantity of atomic solid moves downwards faster than the smaller quantity.¹

Conclusion

In book one of the *De caelo* Aristotle has argued in effect that the atoms approximate to the possession of absolute weight, in so far as the natural implication of his argument there is that if the atoms are heavy absolutely then there can be nothing, he argues, that is light absolutely, and *vice versa*.

Essentially this same conception underlies Aristotle's criticism of the Atomists at the beginning of book four. The difference is that now the atoms are treated as moving consistently downwards, and upward movement is attributed to the void. Aristotle's argument is that a large quantity of fire will have more atoms, or more atomic solid, than a small quantity of earth, and will therefore be heavier. The conclusion is that earth therefore cannot be heavy absolutely.

¹ I hope that, here as later, my use of the expression 'material principle' will not be found confusing. It will be used to cover both $\sigma\lambda\eta$ as in the present argument (iv 5, 312b20–32) and in the argument on the intermediate elements which I shall consider in the section following this (iv 2, 309b32, pp.23–5 below). (In the first argument of the fourth book, 'earth and fire', cap. 2, 309a33–b4, Aristotle avoids using any specific term.)

I have resorted to this periphrasis both in order to allow for the cases where $\sigma\lambda\eta$, for Aristotle, is primarily extension as opposed to body, while at the same time it is not merely space, nor is it of course only an abstraction, even if it can be isolated only abstractly. But these are wider problems: my choice of the expression 'material principle', here and throughout this study, is intended only as a recognition of these further difficulties, not as a solution of them.

In a variation of the same argument, towards the end of book four, Aristotle argues that a large quantity of air would have more solid than a small quantity of earth, so that in this case air would be heavier than earth.

In these arguments from book four, as in the argument from book one, Aristotle's premiss is that the atoms themselves do at least approximate to the possession of absolute weight, since they move consistently downwards, and since the larger quantity is invariably the heavier, two features by which earth, in Aristotle's own system, is recognised as being heavy absolutely.

§ 4—

Classification of the Weight of Atoms: Identification with Absolute Weight

The three arguments against the atomic theory that I have considered so far, from the first book and from the fourth book of the *De caelo*, take as, or include in, their subject elements which should have absolute weight.

There remain a number of criticisms in the fourth book of the *De caelo* which have a similar structure to that of the argument about earth and fire, or earth and air. The difference is that these other arguments turn on the existence of two elements with relative weight, or of bodies with composite weight.

In the course of these arguments Aristotle virtually identifies the atoms with earth in his own system.

Intermediate Elements

In the arguments that I have introduced so far from the *De caelo*, Aristotle takes the atomic system as providing:

1. A single material principle, the atoms: in the argument from the first book.
2. A single material principle, atoms *or* the void: in the arguments from the fourth book that I have called 'earth and fire' and 'earth and air'.

In a brief criticism before the exposition of his own theory in book four of the *De caelo*, Aristotle treats the Atomists as providing two material principles, atoms *and* the void.

This form of argument leads Aristotle to write more or less explicitly of the atoms' having absolute weight, iv 2, 309b33–310a3:
αἰτίαν βαρύτερα καὶ κουφότερα ἀλλήλων καὶ τῶν ἀπλῶς ἔστιν .

'If there is a single material principle, as there is for those who make <everything> out of triangles, then there will not exist <both> what is heavy absolutely and what is light <absolutely>.

'The alternative theory: if there are opposite material principles as those claim who make void and plenum <their starting-points>, then <on this theory void and plenum could be counted as being respectively light absolutely and heavy absolutely, but> the <elemental> bodies intermediate between things heavy absolutely and light <absolutely, namely water and air which are intermediate between earth and fire> will have no reason for being <(1) respectively> heavier and lighter than each other, or <for being (2) jointly heavier and lighter> than the bodies <earth and fire which are respectively heavy and light> absolutely.'¹

¹ It may be objected that the Atomists are not sufficiently identified by the rubric, οἷον εἴ τις φαίη εἶναι τὸ κενὸν καὶ πᾶν (iv 5, 312b33–313a1).

I think myself that this is sufficient identification (I shall argue the point in my essay on Aristotle), but even if it were not, the point would be only incidental to my present argument, for my purpose here is not to establish directly what the Atomists believed, but to determine how Aristotle thought of their system in the light of his own categories of absolute and relative weight. I think it can be fairly argued that the distinction between void and plenum will at least include the distinction between void and atoms, and that this is sufficient for the purpose in hand.

I do not see how to tell whether οὐσης καὶ τινος ὄλης, or the accusative, which seems to fit better with the following phrase, and which is how I have taken it in my reading of the text. Fortunately the sense is not much different.

The argument turns on a distinction between Plato and Democritus.

1. If there is a single undifferentiated material principle, as Plato's triangles are taken to be, then there cannot be a difference between what is heavy absolutely and what is light absolutely, for the same matter could not have natural movement in opposite directions at the same time.
2. If, on the other hand, there are two opposite material principles, which is how Aristotle chooses at this point to categorise atoms and the void, then there would be a body which was heavy absolutely (made of atoms) and a body which was light absolutely (made of void), but there would be no way of explaining the differentiated movements of what is relatively light and relatively heavy, for atoms would move only downwards, and void would move only upwards.

The form of argument brought against Plato is of course precisely the same as that brought originally against Democritus, in the arguments which I analysed earlier, where Aristotle either treats the atoms as being the sole determinant of weight or treats atoms and void as alternative determinants of weight.

On the present interpretation, atoms and the void are treated as opposite and coexistent material principles. The implication is quite plainly that, on this interpretation of the atomic theory, atoms and the void are reckoned as representing, or as constituting, respectively 'bodies which are heavy absolutely and bodies which are light <absolutely>': τῶν ἀπλῶς βαρέων καὶ κούφων.

'Air and Water'

In a final argument, at the end of book four, Aristotle returns to the notion of the atomic system as providing opposite and coexistent material principles.

Aristotle writes, cap. 5, 312b32–313a6: πλεῖτον ἔξει πῦρ ὀλίγου ἀέρος, καὶ ἀήρ πολλὸς ὀλίγου ὕδατος γῆν πλείω, ὥστε

οὐ φαίνεται οὐδαμοῦ οὐδέποτε.

'If there are two material principles <for all things>, then how will the intermediate bodies <air and water> be able to behave as air and water do <in fact> behave?

'Suppose one were to claim void and plenum <as the two material principles of all things>. Then fire <would be equivalent to> void, and so <would move always and only> upwards, while earth <would be equivalent to> plenum, and so <would move always and only> downwards.

'Then suppose that <air and water are made from a mixture of fire/void and earth/plenum, in such a way that> air has more fire <or void>, and that water has more earth <or plenum>.

'<Now from this it follows that air and water cannot behave as they are seen to behave.>

'For <(1)> there will be a <quantity of> water <so large> that <it> will have more fire than a small quantity of air has.

'And <conversely (2)> a large <quantity of> air will have more earth than a small <quantity of> water has.

'<But on this second assumption> it must follow that a certain <quantity of> air <namely a large quantity> will be carried downwards more quickly than a small <quantity of> water.

'But this is never seen to happen anywhere, ever.'

(i)

Aristotle's premiss in this final argument is that there should be two material principles, void and plenum represented by fire and earth respectively. The supposition is that of the two intermediate bodies air will have a preponderance of fire, and water a preponderance of earth.

The impossibility in this theory, Aristotle argues, is that a large quantity of water will have more fire, or more void, than a small quantity of air, while conversely a large quantity of air will have more earth, or more plenum, than a small quantity of water.

1. In the first case, Aristotle's intention is that water would prove to be lighter, in the sense that it will be carried upwards more swiftly, than air.
2. In the second case, the point is that air will be heavier, in the sense that it will be carried downwards more swiftly, than water.

Aristotle's own theory is evidently that, on the contrary, any quantity of air, no matter how small, will always be carried upwards more swiftly than any quantity of water, no matter how large, and that conversely any quantity of water, no matter how small, will always be carried downwards more swiftly than any quantity of air, no matter how large.¹

(ii)

Although the consequence is now expressed in terms of bodies which should have relative weight, and although the criticism now turns on the question of differences of speed, the structure and the assumption of this argument is essentially the same as the struc-

¹ The precise nature of Aristotle's argument at this point has, I think, been misunderstood. I present here the principle required by the form of argument which I claim to reconstruct in my third essay.

I shall there attempt to show that this final argument is the culmination of Aristotle's critique of the atomic theory in that he does here attempt to answer the problem raised by atoms and void as jointly determining the weight of a body; but I shall also attempt to show that the way in which he does so still treats only one or other factor at a time as the active determinant of weight, so to speak, since in either branch of his argument one factor is neutralised, as it were, by the nature of the medium in which the composite body—formed of atoms and the void—is supposed to rise or fall.

I anticipate this point here, only lest the acute reader should be deterred by what might otherwise appear the logical inadequacy of the argument, as I have presented it. My present purpose is solely to show the way in which Aristotle thinks of the atoms in the arguments which he deploys against the theory in the course of book four.

One further *caveat*: when I speak of 'more' fire or of a 'quantity' of water, the scrupulous reader may ask 'by what measured?' In so far as the argument is directed against the atomic theory, the answer is simply 'void' and/or 'the number and size of atoms'. To specify the answer in terms of Aristotle's own theory would perhaps be more difficult, since it would risk rousing the whole mediaeval conception of *quantitas materiae*. But the former answer is, I think, sufficient for the purpose in hand.

ture and the assumption of the first argument which I considered from book four, on the comparison of earth and fire.¹

As before, the lesson of the argument is that the atoms themselves represent, or approximate to the possession of, absolute weight.

1. Aristotle's first argument turned on the notion that the atoms move in a single direction, and that a larger quantity of atoms will be heavier than a smaller quantity.
2. Similarly, the present argument turns on the notion that the atoms have a single movement downwards, and that a larger quantity of atoms moves downwards more swiftly than a smaller quantity.

In either case, Aristotle's point is essentially that a body—'earth' or 'plenum' in this later argument, 'solid' in the earlier argument—which approximates to the possession of absolute weight cannot provide for the distinction between two elements with absolute weight, nor for a distinction between two elements with relative weight. For in either case a body with a larger quantity of plenum or solid will be heavier than, or will move downwards more swiftly than, a body with a smaller quantity of plenum or solid, irrespective of the elements which the two bodies may be supposed to constitute or to represent; whereas in fact, Aristotle supposes, fire in any quantity will be lighter than earth in any quantity, while equally any quantity of air, no matter how large, will move downwards more slowly than any quantity of water, no matter how small.

The difference between the two arguments is that since the conclusion of the present argument turns on the behaviour of air and water, elements which have relative weight, the premiss of the argument is able to treat atoms and void, or plenum and void, as identical with earth and fire in Aristotle's own system, the two elements which are respectively heavy absolutely and light absolutely.²

¹ iv 2, 309a33–b4, pp.16–19 above.

² Lest it be thought this comparison between Aristotle's first and last arguments against the Atomists in book four of the *De caelo* is undesirably syncretistic, perhaps I should add that in general my purpose in this opening chapter is to

(footnote continued on next page)

Composite Bodies

Essentially this same attitude towards the atomic theory is exemplified in two passages where Aristotle distinguishes atoms and void not from elements with relative weight, air and water in his own system, but more generally from composite bodies, such things as wood and bronze.¹

(i)

Towards the end of his long opening series of criticisms of the atomic theory, Aristotle writes, iv 2, 309b18–23: τὸ μὲν κοῦφον, τὸ δ' ἔχει βάρος.

'But perhaps, on the contrary, the point of the theory is that the void is in fact so constituted by nature as to move upwards, while the plenum is by nature so constituted as to move downwards, and that, in virtue of their natures being such, void and plenum are causes in other things of movement in either direction.

'If that is the point of the theory, then the proper course

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stress the similarity, in structure and in general principle, of Aristotle's diverse arguments against the Atomists. In my third essay I shall aim instead to isolate and to explain the differences between these same arguments, and to establish what I believe to be the progression in Aristotle's thought from one argument to the next.

These differences I have narrowed, in my present analysis, essentially to the distinction between arguments where Aristotle denies that the atoms can account for differences between elements which have absolute weight, or for differences between an element which has absolute weight and an element which has relative weight (the two arguments 'earth and fire' and 'earth and air' adduced in § 3 of this chapter) and arguments where Aristotle allows that atoms, or atoms and the void, may represent elements which have absolute weight, and denies therefore that they can account for the behaviour of elements both of which have relative weight (the arguments adduced so far in this section).

¹ This change in the terms of the comparison is more complex than it may seem, and I must therefore reserve a full analysis of these two arguments, and of the difference between them, for my third essay.

was not to take compound bodies <formed from atoms and void> as the primary focus of one's enquiry, and to spend one's time trying to establish why some bodies of this kind are light and why other bodies of this kind are heavy.

'<That was not the proper way of going about things.> On the contrary, the proper course was to concentrate on void and plenum in themselves, and to establish why one of these is light <in itself>, while the other possesses heaviness.'

(ii)

Essentially the same point is repeated several pages later, iv 4, 311a29-b1: τὸ πλήρες τὸ βαρὺ λέγοντας καὶ διὰ τὸ κενὸν τὸ κοῦφον .

'Other bodies <apart from the four elements> are characterised by the possession of heaviness and lightness.

'It is evident that all these bodies possess their characterisation in this respect as a direct result of the difference that exists between heavy and light in the simple, non-composite elements.

'The position is that the simple, non-composite bodies enter to a greater or less extent <into the make-up of non-elemental bodies>, and according to the proportion of the simple elements that there may happen to be in any particular instance the <composite or non-elemental> bodies are constituted as light or as heavy.

'The consequence of this is that it should be the primary and non-composite bodies which form the proper object of our enquiry.

'The point is that other things take their orientation in this respect from the primary elements. This subordination, therefore, as I said earlier, should have determined the procedure of those who claim that what is heavy is so because of the plenum and that what is light is so because of the void.'

(iii)

In these two passages, Aristotle introduces his own distinction between:

1. The four simple elements.
2. Bodies compounded of more than one element.

This distinction he takes to be parallel to the distinction between:

1. Atoms and void.
2. Bodies compounded of atoms and void, including therefore (on the atomic theory) the four cosmic elements.

This arrangement does not lead so clearly to an identification of void and plenum with the two forms of absolute weight possessed respectively by fire and by earth in Aristotle's own system, for strictly the point is now that the two principles of the atomic system have to do duty for all four of Aristotle's own primary elements, air and water as well as fire and earth.

Nonetheless, the formulation which Aristotle employs in the earlier passage does I think make it reasonably clear that here, as in the passage which I have analysed from the end of book four, on the comparison of air and water, Aristotle does think essentially of void and plenum as a pair of principles which will produce movement in opposite directions, and which are therefore obvious candidates for the two elements which have absolute weight in his own system. This will be true, even if that candidature is ratified, as it were, only when Aristotle speaks of void and plenum as opposed to his own two intermediate elements, and therefore as identified with fire and earth in his own system.

Certainly, it would be totally wrong to take Aristotle's account of weight in composite bodies as in any way implying that atoms and void, or plenum and void, should be identified with the intermediate elements in his own system, to the exclusion of elements which have absolute weight. Taken strictly by themselves, the two passages where Aristotle treats of composite bodies in relation to the atomic system are perhaps marginally ambiguous for our present purpose. But such ambiguity as there may be is resolved in quite the opposite sense to that required by Cherniss' interpre-

tation, when in his account of the intermediate elements Aristotle specifically identifies void and plenum with fire and earth in his own system, the two elements which are light and heavy absolutely.

Conclusion

In this and in the preceding section I have outlined the criticisms which Aristotle makes of the Atomists in the course of the fourth book of the *De caelo*.

At no point in Aristotle's criticism of the Atomists is there any ground for concluding, as does Cherniss, that the atoms themselves are reckoned as being only relatively heavy or as having only relative weight.

On the contrary, Aristotle's arguments require that the atoms themselves should be thought of as at least approximating to the possession of absolute weight, in that they are represented as moving consistently downwards, and the larger quantity as being invariably the heavier, the two features by which earth, in Aristotle's own system, is recognised as being heavy absolutely.

Indeed in his final argument against the Atomists in book four of the *De caelo* ('air and water', cap. 5, 312b32–313a6) Aristotle writes explicitly of atoms and void, or of plenum and void, as identical with earth and fire in his own system, the two elements which are respectively heavy absolutely and light absolutely.

§ 5—

'Relative Weight' and 'Absolute Weight' in Aristotle's Criticism of His Predecessors

(i)

There remains a potential conflict.

I quoted earlier two passages where Aristotle asserts that his predecessors, or at least a 'majority' of them, ignored the existence of what is heavy absolutely and what is light absolutely, and spoke only of 'what was heavier and <what was> lighter out of things that have heaviness' or of 'bodies that are heavy and light in the sense only that of two bodies both having heaviness one or the other is the lighter of the two'.¹

¹ The two generalisations, iv 1, 308a9–13 and iv 2, 308a34–b3, pp.7–8 above.

How does this square with the conclusion that in Aristotle's criticism of the atomic theory the atoms themselves are reckoned as having, or at least as approximating towards the possession of, absolute heaviness?

(ii)

Obviously the simplest expedient would be for me to rely on the restriction that I emphasised earlier, whereby in the second of the two opening passages of criticism Aristotle's generalisation is limited to 'a majority' of his predecessors, and whereby in a later passage Aristotle singles out 'certain others' who 'agree' that there does exist a body which is heavy absolutely.¹

But to do so would not be altogether honest. For the truth, I suspect, is that Aristotle does intend the Atomists to be included under the earlier generalisation, as well as being included, from a different point of view, among the 'certain others' who 'agree' in having a body which is heavy absolutely.

'Relative Weight'

Thus if we reflect on the first detailed criticism that Aristotle makes of the atomic theory in book four of the *De caelo*, then we see that it does in fact correspond to the terms of Aristotle's opening and more general criticisms of how people thought in the past.²

For the purpose of Aristotle's first argument against the Atomists is to show that if earth and fire are made from the atoms then either there will be a body which is lighter than fire, or there will be a body which is heavier than earth. In either case, therefore, a body which should possess absolute weight turns out not to do so.

This conclusion conforms precisely to the criticism that in the past people have spoken not of bodies that are heavy absolutely and light absolutely, but only of bodies that are heavier or lighter in relation to something else.³

¹ The second generalisation, iv 2, 308a34–b3, p.8 above; 'certain others', iv 4, 311b14–19, pp.9–11 above.

² The first detailed criticism, 'earth and fire', iv 2, 309a33–b4, pp.16–19 above; the opening criticisms, iv 1, 308a9–13, and iv 2, 308a34–b3, pp.7–8 above.

³ Cf. iv 1, 308a9–13, pp.7–8 above.

More particularly, this first argument against the Atomists would seem to illustrate Aristotle's complaint that, in speaking of bodies where one is lighter than the other, people in the past have thought that they were defining bodies that were heavy and light in an absolute sense, but that their definition 'fails to match <their conception of it>'.¹

For in the course of the *De caelo* Aristotle offers the atomic theory precisely as purporting to provide for a distinction between earth and fire, as respectively heavy absolutely and light absolutely, and as being unable to do so.

'Absolute Weight'

At the same time, Aristotle's criticism of the atomic theory requires that the atoms themselves should be reckoned as having absolute weight, at least in the sense that they have movement all in the same direction. For only so is Aristotle able to argue that a larger portion of atomic solid will be heavier than a smaller portion, and to conclude therefore that if earth and fire are both made from the atoms then a larger quantity of fire will be heavier than a tiny quantity of earth, contrary to his own belief that no substance can be heavier than earth, or lighter than fire.

This feature of the atomic theory comes to the fore when in his later criticism in the *De caelo* Aristotle speaks of atoms and the void as representing opposite forms of absolute weight, and of the atoms as corresponding to earth in his own system. This is the supposition in those arguments directed to show that the Atomists cannot account for the distinction between earth and air, or between air and water. It is also, I have argued, essentially this same assumption which underlies Aristotle's more general complaint that the distinction between atoms—or plenum—and void has not been properly exploited to explain the differences of weight in composite bodies.²

When Aristotle criticises the atomic theory in these terms, then I think it is likely that the Atomists can be, and therefore proba-

¹ Cf. iv 2, 308a34–b3, p.8 above.

² 'Earth and air', iv 5, 312b19–32, pp.20–3 above. 'Air and water', iv 5, 312b32–313a6, pp.25–8 above. 'Composite bodies', iv 2, 309b18–23 and iv 4, 311a29–b1, pp.29–32 above.

bly are, included among the 'certain others' who 'agree' that there does exist a body which is heavy absolutely.¹

The Two Classifications

(i)

Thus I conclude that from different points of view the Atomists can be, and probably are, included in both the classifications that I noted earlier.

1. In his first criticism of the Atomists in the fourth book of the *De caelo*, Aristotle complains that the atoms cannot produce bodies with absolute weight, earth and fire: bodies formed from the atoms, which should have absolute weight, prove not to do so.
2. In the later criticisms in book four, Aristotle denies that atoms can produce elements with relative weight, in his own technical sense, and complains that they have not properly been exploited to explain bodies with composite weight: for these purposes, Aristotle treats the atoms as having absolute weight, and as being equivalent to earth in his own system.

¹ 'Certain others', iv 4, 311b14–19, pp.9–11 above.

I conclude that if the Atomists *can* be included in Aristotle's criticism, then they probably *are* included, because I suppose that Plato and the Atomists are the principal, if not the only, targets of Aristotle's criticism throughout the fourth book of the *De caelo*: but this conclusion I must leave to be established in my third essay.

In attempting to summarise Aristotle's criticisms, I have run together (1) the argument where the atoms cannot account for the distinction between an element with absolute weight and an element with relative weight, and (2) the argument where the atoms cannot account for the distinction between two elements which both have relative weight. (1) In the first case ('earth and air', iv 5, 312b19–32), the atoms constitute earth, but 'earth' is then shown not to have absolute weight. (2) In the subsequent criticism ('air and water', iv 5, 312b32–313a6), as in an earlier criticism ('intermediate elements', iv 2, 309b33–310a3), the atoms are identified with earth, but the claim of 'earth' to absolute weight is not refuted, for the criticism now turns on the inability of the theory to explain the relative weight of the intermediate elements.

The *first* point of view is sufficient to include the Atomists among the 'majority' whom Aristotle criticises at the opening of book four as having failed to distinguish elements with opposite forms of absolute weight.

At the same time, the treatment of the atoms in the *later* group of criticisms justifies the inclusion of the Atomists among the 'certain others' who 'agree' that there does exist a body with absolute heaviness, but who do not appreciate that there must also exist a body which is light absolutely.¹

(ii)

This double attitude towards the Atomists is perhaps less odd than it may seem at first sight, if we recognise the feature that is common to both sets of criticisms.

Aristotle's point in his opening pair of criticisms is ultimately that earlier thinkers have failed to provide a distinction that will include the existence of an element which is light absolutely. For the distinction between heavy and light in earlier theories is a distinction that falls within 'bodies that have heaviness', and where therefore there cannot exist an element which is light absolutely. The restriction in earlier theories is the result of no one's having recognised, as a radical alternative to 'bodies which have heaviness', a body which would be light absolutely, as is fire in Aristotle's own system.²

¹ It might be objected that if the Atomists are to be included among those who reckon that there is something heavy absolutely in virtue of the identification of atoms with earth, then equally they should be held to have recognised the existence of an element which was light absolutely in virtue of the identification of void with fire.

But this is not, I think, the kind of consistency that we should look for in Aristotle's criticism. Atoms and void can 'stand in' for earth and fire, as it were, for the purpose of one criticism ('intermediate elements', iv 2, 309b33–310a3, 'air and water', iv 5, 312b32–313a6), and in a similar fashion void can be treated as a 'material principle', by means of which the Atomists purport to establish an element which would be light absolutely (iv 5, 312b21ff.): in both cases void is treated as one of a pair with plenum, or with atoms, in order to provide a conceptual rival to Aristotle's own theories. But the void is still the void, so to speak. In his more general criticism ('certain others', iv 4, 311b14–19), it is, or so it seems to me, both possible and natural for Aristotle to ignore the 'void', taken on its own, as a serious rival to his own conception of fire as light absolutely.

² Cf. iv 1, 308a9–13, and iv 2, 308a34–b3, pp. 7–8 above.

This is the same as Aristotle's complaint against the 'certain others', who are also unaware of the existence of a body which is light absolutely. The difference is that in this case the people whom Aristotle has in mind do specifically recognise a body which has absolute heaviness.¹

The difference between the two groups therefore is that the 'majority' deals only with bodies that are 'lighter' or 'heavier and lighter among bodies that have heaviness', while 'certain others' recognise a body which is heavy absolutely. What both groups have in common, is their failure to recognise a body that is light absolutely.

It is this same failure which, in Aristotle's eyes, characterises the behaviour of atoms in the atomist system. The atoms themselves must have movement all in the same direction. In the first book of the *De caelo*, Aristotle is willing to allow that this may be movement in either direction, up or down. But in the criticisms of the atomic theory in the fourth book upward movement is the effect of void, and the atoms themselves are recognised only as moving downwards.

(iii)

At the same time, here as elsewhere, there is an ambiguity in Aristotle's attitude towards the atoms as 'elements'.

1. The atoms may be treated as elements *prior* to Aristotle's own cosmic elements, including fire and earth.
2. Alternatively, atoms, or atoms and the void, may be *identified* with Aristotle's own elements, usually with the extreme elements, earth, or earth and fire, and treated therefore as prior only to the intermediate elements, or to the composite bodies which in Aristotle's system are formed from the elements.

This explains why the Atomists can be included in both criticisms.

From the *first* point of view, where the atoms are accounted as elemental particles prior to the formation of fire and earth, then

¹ Cf. iv 4, 311b14–19, pp.9–11 above.

fire and earth can be shown to have less than absolute weight, for there can always be a certain quantity of atomic solid which is heavier than what is supposedly absolutely heavy, or lighter than what is supposedly absolutely light.

Alternatively, Aristotle's complaint is that the Atomists cannot account for the distinction between opposite forms of relative weight, and in this process the atoms themselves are allowed to be equivalent to earth in Aristotle's own system.

The distinction, however, is a distinction of attitude and emphasis, and not of substance. Even in the *first* criticism it is only bodies formed from the atoms which are proved not to have absolute weight, while the atoms themselves are treated as at least approximating to the possession of absolute weight, in that they move always downwards, and in that the larger quantity is invariably the heavier; while in the *later* criticism the atoms are identified with earth and are therefore specifically treated as 'moving always towards the centre'.

Both attitudes towards the atomic theory are therefore manifestations of a single critical impulse. In either case, the point is that the atoms have all the same nature, and that they cannot therefore account for the distinctions of heavy and light that are required in Aristotle's own philosophy.¹

¹ I am not aiming here to give an exhaustive account of Aristotle's general criticism. I should perhaps add however that I do believe that Plato is included among the 'certain others' who 'agree' that there is a body which is heavy absolutely, and indeed I suspect that it is Plato's presence here which may have encouraged Aristotle to think of both earlier theories, that of Plato and that of Democritus, as both alike providing an essentially monistic theory, which will allow for the existence of absolute heaviness, but not for the existence of absolute lightness. For despite the fact that in Plato's system earth travels by nature to the centre, and fire to the circumference, Aristotle nonetheless, or so I shall argue, treats the triangles which constitute both elements as heavy absolutely—in Theophrastus' expression (*De sens.* 88), Plato's definition 'applies only to substances of an earthy nature'.

And yet Plato's triangles, or so I shall also argue, are included in the argument which proves that air is heavier than earth (iv 5, 312b19–32). Hence the ambiguity. From one point of view, *no one* has recognised the existence of elements with absolute weight (cf. οὐδὲν εἴρηται, iv 1, 308a10). For the philosophers who do recognise an element which is heavy absolutely are the *same* as those who fail to do so, only looked at from a different point of view.

However, Aristotle's criticism of Plato has, I believe, been even more radically misunderstood than has his criticism of Democritus, and I must therefore leave the conjunction of Plato and Democritus for my second and third essays.

Conclusion

My decision to include the Atomists in both Aristotle's general criticisms, against the 'majority' and against the 'others', is influenced by the conclusion that I shall argue to later, in the earlier of my two essays on Aristotle, that the only two explicitly philosophical theories of weight known to Aristotle were those of Plato and the Atomists. Therefore although Aristotle's opening statements in book four could be taken as directed only or primarily against those who have 'used' heavy and light, and not against the 'few' who have 'defined their powers'—to repeat the distinction which Aristotle introduces in the opening sentences of his treatise (308a3–4)—nonetheless I am reluctant to think that one of Aristotle's two main adversaries should have been excluded from his condemnation of 'how people have thought in the past'.

As it is, it seems to me that in criticising earlier thinkers for considering only 'what is heavier and <what is> lighter among bodies that have heaviness' Aristotle will in fact most likely include the Atomists in his calculation, but only in virtue of the behaviour of bodies that are formed from the atoms, i.e. in so far as the atoms purport to provide a distinction between two elements with absolute weight, or between an element with absolute weight and an element with relative weight, and not in virtue of the behaviour of the atoms themselves.

For in his later criticism of the atomic theory, as unable to provide for the existence and behaviour of elements with relative weight, and as not accounting for the weight of composite bodies, Aristotle reckons the atoms themselves as having absolute heaviness, and as corresponding to earth in his own system. From this point of view, the Atomists can be, and probably are, included among the thinkers who 'agree' with Aristotle that there does exist a body with absolute heaviness, but who fail to see that there must also exist a body which is light absolutely.

Odd, therefore, though it may seem at first sight, I conclude that the Atomists can be, and therefore probably are, included both among the 'majority' who ignore the distinction between elements with opposite forms of absolute weight and, from a different point of view, among the 'certain others', who recognise the existence of an element which does have absolute heaviness.

The reason for this seeming anomaly is that the atoms may be

regarded either as prior to the cosmic elements, or as identical with earth in Aristotle's own system: in the first case, Aristotle's criticism is that earth and fire in the Atomists' system cannot have absolute weight; in the second case, the criticism is that the Atomists cannot account for relative weight. In both types of criticism, the assumption is that the atoms themselves may be regarded as possessing, or as approximating to the possession of, absolute heaviness.

There is therefore no ground, it seems to me, for concluding, as Cherniss has done, that in the *De caelo* the atoms themselves are deprived of absolute weight. On the contrary, Aristotle's general classification of earlier theories, if it includes the Atomists, will apply only to bodies that are formed from the atoms, while the detailed criticisms which Aristotle makes of the atomic theory, throughout the *De caelo*, require that the atoms themselves should be regarded as having, or at least as approximating to the possession of, absolute heaviness.

Chapter Two— Aristotle 'De Generatione et Corruptione'

I turn therefore to the two passages, from the *De caelo* and from the *De generatione et corruptione*, where Aristotle writes not simply of plenum, or of plenum and void, but more specifically, or so I shall argue, of the weight of individual atoms. I take first the passage from the *De generatione et corruptione*. This passage occurs in a series of arguments designed to show that the atoms cannot truly be without the capacity to act or to be acted upon.

Aristotle writes that Plato and the Atomists both explain coming into being by the use of elements that are indivisible and that are defined only by their shapes, with the two differences, firstly that Plato's individual elements are surfaces while those of the Atomists are solids, and secondly that for Plato contact is the only way by which things can be generated or dissolved, while the Atomists have two methods at their disposal, contact and the void. Plato's version of the theory, Aristotle adds, has already been criticised. It is now the turn of the Atomists.¹

Only the first section of Aristotle's series of criticisms is relevant to our purpose, i 8, 325b36–326a14 (in part only DK 68A60): (326a12). ἀλλὰ μὴν εἰ

¹ This summarises *De gen. et corr.* i 8, 325b24–36 (in part DK 67A7).

σκληρόν, καὶ μαλακόν. τὸ δὲ μαλακὸν ἤδη τῷ πάσχειν τι λέγεται· τὸ γὰρ ὑπεικτικὸν μαλακόν.¹

The confusion that surrounds the interpretation of these seemingly simple words is not untypical of the confusion that seems to be ingrained in the whole question of atomic weight. One may wonder whether two hundred years of scholarship have done anything to lessen the force of Tiedemann's comment, that the interpretation of Aristotle's remark 'heischt fast mehr als einen Oedipus'.²

A general difficulty is formulated by Dyroff: 'Jedes Atom kann doch nicht schwerer sein als das andere'.³ Two more particular difficulties lie in the interpretation of κατὰ τὴν ὑπεροχήν: in what sense is each atom 'heavier' according to its 'preponderance'?

In the first section of this chapter I shall consider only the simpler of these two more particular problems: the immediate sense, in this context, of ὑπεροχή.

The questions surrounding the meaning of βαρύτερον will require us to draw on the conclusion of my preceding chapter; for the way in which Aristotle writes, and thinks, of the atomic theory in relation to his own conception of heavy and light will provide, I believe, an essential clue to what Aristotle means by saying that 'each' atom is 'heavier' than another.

¹ My rendering of the Greek is given after the analysis, pp.77–9 below. For the reading θερμόν (326a12) see below pp.64–6.

² Dieterich Tiedemann, *Geist der spekulativen Philosophie* i (Marburg, 1791) 268. Léon Robin writes of Democritus' theory of weight as 'une question particulièrement épineuse', which 'reste en somme indécise', 'L'atomisme ancien', *Revue de synthèse* 6 (1933) 211 (= *Pensée hellénique* 74–5). Paul Moraux, in the Introduction to his Budé edn of the *De caelo*, cxlv: 'Le problème est, à vrai dire, fort complexe, surtout à cause des contradictions de nos sources. . . . contradictions, qui ont fait naître une littérature assez considérable'.

³ *Demokritstudien* 33 n.2.

§ 1—
'Preponderance'

I turn first then to the simpler of the two more particular problems that I noted: the meaning, in this context, of ὑπεροχή.

(i)

I translate ὑπεροχή.

I have deliberately avoided the common translation 'excess', used for example by Burnet and repeated by Professor Kirk, since, as the instructive use of the verb in Plato's *Phaedo* makes clear (102B–D), the idea is primarily that there is *more* of one thing, and not necessarily that there is *too much* of it. Simmias is taller than Socrates, and Phaedo is the tallest of the three. But there is no implication that Simmias or Phaedo is in any way unduly or 'excessively' tall.¹

The point may seem a trivial one, but the mistranslation, though slight, easily leads to the notion that there is some norm, above which, or in excess of which, an atom acquires a special kind of weight, which is the assumption made explicit in Brieger's interpretation, noted immediately below.

As it is, my point is not of course that κατὰ ... τὴν τῶν φερομένων ὑπεροχὴν (iv 8, 216a11–16) means simply that a body will move more quickly or less quickly according as it is more heavy or less so, more light or less so. As in the *Phaedo*, there is no connotation of the body in

¹ Burnet, *EGP* 342. Geoffrey S. Kirk, *The Presocratic philosophers* (Cambridge, 1957) 414. The use of the verb 'exceeds', as in Harold H. Joachim, translation of the *De gen. et corr.* in *The works of Aristotle translated into English* ii (Oxford, 1930), perhaps avoids this difficulty, but makes it a trifle difficult to keep close to Aristotle's own formula.

question being unduly, or even unusually, fast or slow, heavy or light.

Similarly, when in the fourth book of the *De caelo* Aristotle remarks that 'a change in something susceptible of growth leads to an increase of size', ὑπεροχὴν (iv 3, 310b20–1), he does not mean that the object becomes in any way unduly or 'excessively' large, simply that it becomes larger than it was before. Equally, in the present context, there need be no conception of a 'norm' of heaviness, beyond which anything that is heavier is so 'in excess'—the assumption reflected in Kirk's rendering, and present explicitly in Brieger's interpretation.¹

(ii)

Brieger, in the later of his two studies of the atomic theory of weight, claims that the atoms are heavier than what is compounded of the atoms:

'Für die Alten war das Gold das schwerste Metall. Sein spezifisches Gewicht beträgt bekanntlich 19,35, das Gewicht des Atoms würde also $19,35 + x$ sein. Dies x ist die ὑπεροχή des Atoms gegenüber dem Golde.'²

¹ A useful corrective to the assumption that ὑπερ are usually translated with a pejorative sense, Jarkho concludes that this is 'neither the original meaning of these adjectives, nor that the most frequently observed. . . . The pejorative meaning was not inherent in the adjectives, adverbs or participles as such . . . ' (from the English summary, p. 86).

Even in later Greek the notion of 'excess' is by no means invariable: a wide range of examples from fifth- and fourth-century authors is included in Gerhard Delling, 'Zum steigenden Gebrauch von Komposita mit ὑπερ bei Paulus', *Novum testamentum* 11 (1969) 127–53.

² Adolf Brieger, 'Die Urbewegung der Demokritischen Atome' (henceforward 'Urbewegung'), *Philologus* 63 n.F. 17 (1904) 585–6. Brieger's earlier work is *Die Urbewegung der Atome und die Weltentstehung bei Leucipp und Democrit* (henceforward *Urbewegung*), in *Jahresbericht des Stadtgymnasiums zu Halle A/S von Ostern 1883 bis Ostern 1884*.

Apart from the anachronism of the example and the complexity of the concept, this interpretation seems to me excluded by the context. The conclusion of the argument is that the atoms are acted upon by each other ((ὕπ' ἀλλήλων)), which indicates that the premiss has to be that one atom is heavier, or hotter, than another, and not that the atoms are in some way heavier or hotter than the substances which are formed from them.¹

(iii)

One other eccentric interpretation of κατὰ τὴν ὑπεροχήν is perhaps worth recalling. Charles Renouvier writes:

'La seule pesanteur qui appartienne aux corps indivisibles, c'est la *pesanteur par excès* (κατὰ τὴν ὑπεροχήν), c'est-à-dire la force qui résulte de l'impulsion par un volume supérieur d'un volume moindre, qui vient à être abordé par lui.'²

While there may be some truth in Renouvier's general conception of atomic weight, I think that this is again too much to read into the context of Aristotle's phrase.³

(iv)

That the sense of preponderance does not in itself require any very elaborate, or exotic, interpretation is perhaps sufficiently indicated by Aristotle's use of the same expression in his account

¹ A similar consideration excludes the interpretation which is perpetuated in Bonitz's *Index Aristotelicus* (Berolini, 1870) 134a17–18, where the order of words implies that each compound body is heavier according to the 'preponderance' of atoms which it contains. But not only is it impossible for ἀναγκαῖον ἀπαθές τε ἕκαστον λέγειν τῶν ἀδιαίρετων (325b36–326a1), as is rightly noted by O. Hamelin, 'La pesanteur de l'atome dans le système de Démocrite', *Annales de la faculté des lettres de Bordeaux* (1888) 198 n.1. It is the individual atoms, and not the substances formed from them, which are the target of Aristotle's criticism throughout the passage.

² *Manuel de philosophie ancienne* i (Paris, 1844) 245–6.

³ For the place I give to Renouvier's general conception of weight see below pp.348–50.

of Plato's theory of weight. In Plato's theory, Aristotle tells us, 'each thing is heavier depending upon its preponderance of equal parts', *De caelor* iv 2, 308b9: ἑκαστόν ἐστιν.

The immediate difference between this formulation of Plato's theory and Aristotle's account of Democritus is that the subject of Plato's theory is a compound body, and not the individual primary particles or parts.

We cannot therefore apply the formula which Aristotle uses for Plato directly to Democritus: for since Democritus' atoms do not have 'parts' it would obviously be impossible to explain Aristotle's expression, in the case of Democritus, as a preponderance of the number of 'equal' or identical parts.¹

But Democritus' atoms do differ in size.² Ὑπεροχή, we may wish to conclude therefore, will mean, for Democritus, a preponderance not of the *number* of identical parts, but of the *size* of each individual particle.

(v)

This is in fact the commonest modern interpretation. For example, Professor Guthrie translates:

'Each atom is heavier, the bigger it is.'³

But against just such a rendering Cherniss has rightly argued that ὕπεροχή takes its more specific reference from the context, and that since in Aristotle's argument there is no mention of size the expression does not necessarily mean, and cannot therefore in

¹ On the question of the 'parts' of atoms—a conception introduced into the earlier theory by Epicurus—see further pp.213–14 and 270–9 below.

² Aristotle, κατὰ μέγεθος διαφοράς, *ap. Simpl. De caelor* 295.7–8 (fr. 208 Rose = DK 68A37). Cf. *Phys.* iii 4, 203a33–b2 (DK 68A41).

³ William K. C. Guthrie, *A history of Greek philosophy* (henceforward *History*) ii (Cambridge, 1965) 503.

Among others who take ὕπεροχή in this way I note the following: Friedrich W. A. Mullach, *Democriti Abderitae operum fragmenta* . . . (Berolini, 1843) 347, Brieger, *Urbewegung* 5, Harold H. Joachim, in the notes to his edition of the *De gen. et corr.* (Oxford, 1922) 165, and in a note to his Oxford translation, though not in the translation itself, Bailey, *Greek Atomists* 130 and 144, Kirk, *Presocratic philosophers* 414.

There is a difference between taking ὕπεροχή to mean in itself, and of its own

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itself—whatever it may imply—properly be translated as, 'excess magnitude'.¹

Cherniss himself argues that καθ' ὑπεροχὴν καὶ ἔλλειψιν. He then translates:

'Democritus says that each and every atom has relative weight when compared (with any other).'²

(vi)

There are however a number of difficulties in Cherniss' own translation, of which I consider, for the moment, only the difficulty relating to Cherniss' translation of ὑπεροχή.

In translating ὑπεροχή to preponderance, or deficiency, specifically and exclusively of weight:

'Each and every atom has relative weight when compared with any other (*sc.* in respect of weight).'

But we have scarcely more right to contract ὑπεροχή to mean 'in preponderance of weight', which admittedly has specific reference to the context, but is otiose in sense, than we have to expand it to mean 'in preponderance of size', which is not otiose in sense, but has no specific reference to the existing context.

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right as it were, preponderance or excess of size or bulk, which I think is what all the authors cited so far intend; and supposing that in the light of other evidence this is the sense that may be added to εἰ τὰ μείζω ἄτομα βαρύτερα, in the course of his elaboration of Aristotle's argument.

In neither case have I distinguished between those who write of a preponderance of bulk or mass and those who write of a preponderance of size or volume.

¹ ACP 97 n.412

² ACP 97 n.412. For ὑπεροχή as an abbreviation, Cherniss cites two pairs of passages: *Hist. anim.* i 1, 486a21–b17 with iv 4, 528b13–14, and *De part. anim.* i 4, 644a16–23 with i 5, 645b22–6.

(vii)

The truth, I suggest, is quite simply that the particular nature of the atoms' 'preponderancy' is here left open. 'Ὑπεροχὴ' need not look back, tautologically, to weight; nor need it refer specifically to size, although there is of course nothing to preclude this latter implication.

Admittedly, if 'Ὑπεροχὴ' does not mean merely 'comparison', then we might well wonder what kind of preponderance or difference it could imply in this context, if not that of size. Moreover, since other evidence will show that for Democritus the weight of atoms was in fact proportionate to their size, and that Aristotle knew this, then to disallow that connotation in the translation of the present passage may seem unnecessarily scrupulous.

But for the sake of accurate exegesis it is as well, even though avoiding Cherniss' own translation, to accept his negative point, that 'Ὑπεροχὴ' need not in itself mean preponderance of size, while adding the *caveat* that such an implication is in no way excluded.¹

Conclusion

My first conclusion is therefore, I hope, innocuous enough. Aristotle's statement in the *De generatione et corruptione*, that 'each of the atoms is heavier according to its preponderance', has been a constant source of confusion and of controversy. The simpler point in Aristotle's sentence, the meaning of 'preponderance', can be settled reasonably easily. The term should not be reduced to mere comparison of weight, as in Cherniss' interpretation, nor need it in itself necessarily mean 'preponderance of size', although in the light of other passages that implication may not be precluded. In the present passage, the nature of the atoms' 'preponderancy' is quite simply left open.

¹ The interpretation which Cherniss gives of this passage has already been extensively criticised by Willem J. Verdenius and Jan H. Waszink, *Aristotle on coming-to-be and passing-away, some comments*, in the series *Philosophia antiqua* i, 2nd edn (Leiden, 1966) (henceforward *Comments*) 42–3. Their criticism coincides in part with my own, especially on the point that Cherniss' translation of 'Ὑπεροχὴ' provides 'a rather awkward pleonasm'. See also p.100 n.1 below.

§ 2—

'Relative Weight': Confusion in Cherniss

A second and more serious difficulty in Cherniss' interpretation lies in his translation of βαρύτερον therefore, if it is to be interpreted in terms of Aristotle's own theory, cannot but mean that the atoms have relative weight.¹

At the same time, the translation of βαρύτερον as 'relative weight' touches off a series of more particular misunderstandings, at once conceptual and exegetical. These more particular difficulties also need to be considered in some detail, since the removal of the difficulties exemplified by Cherniss is essential not only for a proper grasp of the present passage, but no less for a clear understanding of Aristotle's evidence on weight as a whole.

(i)

Thus to justify the sense of 'relatively heavy' for τὸ κουφότερον, in the passage which Cherniss cites, does not in fact mean 'what is relatively light', as he supposes.

A detailed study of the passage I shall leave for my later essay on Aristotle. Briefly, Aristotle writes that what is light absolutely is always lighter, but that 'what is lighter' is not always light absolutely. His point is that the use of the comparative may designate either what is absolutely light, or what is relatively so. Grammatically, τὸ κουφότερον must therefore embrace *both* what is

¹ ACP 97–9, esp. 97 n.412, and 209–13; cf. pp.6–7 above. I have myself added the stipulation, 'if it is to be interpreted in terms of Aristotle's own theory'; for Cherniss, this stipulation is too obvious to need stating. As will be seen (§ 3, pp.57–69 below), I do think that there is some truth in the assumption, in this instance.

² ACP 97 n.412. Aristotle, *De caelo* iv 2, 309b6.

absolutely light *and* what is relatively so: it cannot mean only 'what is relatively light'.¹

(ii)

But this is only a preliminary difficulty. 'Heavy' is ambiguous. It may mean 'heavy' as opposed to 'light', or it may be a neutral term, which covers both heavy and light, equivalent therefore to 'weight'. There is the same ambiguity in several other terms of measurement, in Greek as in English: speed, length, breadth, depth.²

This ambiguity conceals a potential discrepancy between Cherniss' argument and his conclusion.

1. From the comparison with βαρύτερον means 'relatively heavy'.
2. On the other hand, in his translation Cherniss writes of 'relative weight'.

The shift from 'relatively heavy' to 'relative weight' at once opens Cherniss' translation to two interpretations.

1. Each atom may have 'relative weight' as distinct from having 'absolute weight'.
2. Each atom may have 'relative weight' in the sense of being 'relatively heavy' as distinct from being 'relatively light'.

The *first* way of taking Cherniss' translation resolves the difficulty noted by Dyroff, for the meaning now is that each atom has 'relative weight', in the sense that it may be heavier *or* lighter than another. But this translation does not follow from the—alleged—comparison with κουφότερον.

The *second* way of taking Cherniss' translation follows from the—alleged—comparison with κουφότερον, but it does not make

¹ This and a second, more complex, passage, also quoted by Cherniss, *De caelo* iii 1, 299b1–4, are considered at length in my third essay.

² Aristotle notes the ambiguity, *Met.* I 1, 1052b24–31. I have touched on this topic in a contribution, 'Aristote: quantité et contrariété; une critique de l'école d'Oxford', forthcoming in *Concepts et catégories* (ed. P. Aubenque).

sense in itself. For if we keep to the restricted meaning of relative weight, which is the only meaning which follows from Cherniss' argument, then we are at once trapped in Dyroff's difficulty, although this was what Cherniss had set out expressly to avoid:

'Each and every atom has relative weight (i.e. is relatively heavy) when compared with any other.'

(iii)

More particularly, this *second* meaning for βαρύτερον controverts the whole sense of Aristotle's distinction between relative weight and absolute weight.

As I have already noted, Aristotle's theory of relative and absolute weight, in its simplest form, is that fire is light absolutely because it moves always upwards, and does so more quickly, and is therefore lighter, in the larger quantity; and that earth is heavy absolutely because it moves always downwards, and does so more quickly, and is therefore heavier, in the larger quantity; while air and water are each of them relatively light and relatively heavy because they move upwards in the region of earth and downwards in the region of fire.¹

From this it follows that what is 'relatively heavy', in Aristotle's theory, is something that will move downwards in relation to one thing (air or water in relation to fire) but not in relation to another (air or water in relation to earth). But if each atom is 'relatively heavy', i.e. moves downwards, 'when compared with *any* other' (my italics), as in this version of Cherniss' translation, then it will be absolutely heavy and not relatively heavy.

'Relative Weight' and 'Absolute Weight'

The truth is, I suspect, that Cherniss has seized upon the meaning of 'relatively heavy' or of 'relative weight' for βαρύτερον in part because he is uncertain, in his own mind, as to the more precise limitations of the Aristotelean theory, so that he finds it

¹ This summarises *De caelo* iv 4, 311a15–29; cf. pp.6–7 above.

easier than in truth it is to chance upon the Aristotelean conception of relative weight.¹

(i)

Thus in the first place Cherniss has by implication confused 'absolutely heavy' and 'relatively heavy', in Aristotle's sense, with the simple positive and comparative, 'heavy' and 'heavier'. For Cherniss writes of absolute heat and relative heat as indistinguishable in status from absolute weight and relative weight.²

But the truth is that Aristotle has no special theory of absolute and relative heat. Something which has absolute heat is therefore, in Aristotle's philosophy, no different in principle from something which is merely hot, while something which is 'relatively' hot is no different from something which is merely hotter than, or 'in relation to', something else.

Clearly, once this confusion has been allowed to enter, then anything which is 'heavier' may be deemed, without more ado, to be 'relatively heavy'.³

(ii)

Secondly, Cherniss has evidently confused the notions of absolute heaviness and maximum heaviness.

1. On Aristotle's theory, earth has absolute heaviness because its natural motion carries it always towards the centre. This does not prevent earth having differences or degrees of heaviness, for a larger quantity of earth will travel down-

¹ In what follows, I have assumed that the expressions 'relatively heavy' and 'relative weight' in Cherniss are intended to represent Aristotle's technical sense of relative, as distinct from absolute, weight. This seems fairly clear from the context of Cherniss' discussions, *ACP* 97–8, 209–13.

It might perhaps be argued, on behalf of Cherniss, that 'relative' weight may be used to describe any comparison where one body is 'related' to another in terms of weight. But such a usage would need to be marked explicitly, as having only a weaker sense; and some other expression would have to be introduced to describe Aristotle's conception of relative, as opposed to absolute, weight.

² *ACP* 97–8, esp. 98 n.413.

³ The confusion is in fact worse than it appears. For having failed to appreciate Aristotle's point about the distinction of meaning in τὸ κωφώτερον (*ACP* 97

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wards more swiftly than a smaller piece, and the larger quantity is therefore heavier than the smaller.

2. However, Cherniss complains at one point that Aristotle should not have allowed differences of weight between different volumes of an element which is heavy absolutely.¹

This criticism betrays that Cherniss has confused, in his own mind, absolute heaviness, in Aristotle's sense, and maximum heaviness.

1. The antithesis of absolute weight, in Aristotle's sense, is relative weight, which is constituted by an element having natural movement in two directions, in the manner that I have delineated.
2. The antithesis of maximum weight is simply anything with less than maximum weight, anything therefore with degrees of weight.

If absolute weight is confused with maximum weight, then anything with less than maximum weight, anything with degrees of weight, will be confused with relative weight.

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n.412, cf. *De caelo* iv 2, 309b6), Cherniss supposes that the comparative θερμό-τερον will mean relatively hot even when it is used to describe a body which is hot absolutely. Thus he writes that since Aristotle 'has admitted that some (sc. atoms) have heat absolutely, each and every atom must have relative heat in comparison with any other' (*ACP* 98 n.413). But this conception of absolute and relative heat cannot correspond to Aristotle's conception of absolute and relative weight, as at this point Cherniss plainly intends that it should. For it is clear that in Aristotle's theory absolute and relative weight are mutually exclusive categories. An element which is heavy absolutely is 'heavier' than another, but it does not therefore possess what Aristotle means by relative weight.

It is true that in denying that Aristotle has any theory of absolute and relative heat I am slightly simplifying the question, for in the *De generatione et corruptione* Aristotle does distinguish what is ὡς μὲν θερμόν ψυχρόν, ὡς δὲ ψυχρόν θερμόν (ii 7, 334b8–20). In my essay on the interpretation of Aristotle's theory I shall return to this passage, and attempt to show the radical difference that there is between Aristotle's theory of the *mixture* of hot and cold and his conception of what is *relatively* heavy and light.

Meanwhile, I hope that I am not being unfair in leaving this passage out of account in my criticism of Cherniss. I think it is fairly clear that in fact Cherniss has been led to talk of the distinction between absolute and relative heat only through his misunderstanding of the conjunction of temperature and weight in the present passage: on this point see further pp.58–61 and 64–9 below.

¹ *ACP* 212 n.255.

A difference of heaviness in the atoms will then of itself appear sufficient to designate some of the atoms as being 'relatively heavy' or as having 'relative weight'.¹

(iii)

Finally, Cherniss has evidently confused 'relatively heavy' and 'comparatively heavy'.

To support his meaning of 'relatively heavy' for νεώτερος to mean 'verhältnismässig jünger', 'fairly young' or 'comparatively young' or even (but not necessarily in Aristotle's technical sense) 'relatively young'.²

¹ The same confusion has affected Bailey, who writes, *Greek Atomists* 131: Aristotle 'never associates with Democritus the conception of absolute weight, but only speaks of atoms as "heavier" or "lighter" than one another'.

Except in the argument from book one of the *De caelo* (cap. 7, 275b29–276a6, cf. pp.11–15 above), Aristotle does not in fact speak of one atom as *lighter* than another. In the fourth book, it is only in the comparison of groups of atoms, which are taken as representing different elements, and in conjunction with the use of void, that Aristotle writes of one group as being lighter than another, as in the argument from the comparison of earth and fire, *De caelo* iv 2, 309a33–b4, cf. pp.16–19 above. One atom being *more heavy* or less so than another does not prevent the atoms having absolute weight in Aristotle's system. It appears to do so, only if we confuse absolute weight and maximum weight.

It is true that in criticising Cherniss on this point I have again slightly simplified my account, for Cherniss makes his remark, on the impropriety of allowing differences of weight for different volumes of an element which has absolute weight, in the context of differences of speed. I shall argue in my third essay that Aristotle has essentially two criteria of weight, speed and displacement. Cherniss' remark would be true of weight as defined by displacement, for on this criterion any and every particle of earth has heaviness in the same sense and to the same degree. But it is not true when weight is measured by speed, for on this criterion different volumes or different quantities of the same element differ in weight.

In general the point remains that Aristotle's conception of absolute weight does not exclude there being different degrees of weight. All earth has absolute heaviness, even though (judged by the criterion of speed) a larger portion of earth will be heavier than a smaller portion. What is excluded by the definition of earth as heavy absolutely is the possibility of any portion of earth being reckoned as 'light' or 'lighter'. It would seem to be an obscure, and confused, recognition of this disjunction which has led Bailey to oppose 'absolute weight' to the notion of the atoms' being "heavier" or "lighter" than one another'. On this point see further pp.63–6 below; a full analysis must await my third essay.

² *ACP* 97 n.412. For this use of the comparative see Kühner-Gerth, *Griechische Grammatik* ii 2, 306 (cited by Cherniss).

Now I do think that this comparison points to one element, and an important element, in Aristotle's conception of relative weight. For it is true that the colloquial use of the comparative and the use of the comparative in Aristotle's description of relative weight are both alike distinct from the simple comparative in that neither is intended as an intensified form of the positive. To simplify the point:

1. The element which is βαρύς¹.
2. So too, the person who is νεός.

From this it follows that in both cases there is, at least by implication, a double reference: the person who is νεώτερος 'comparatively young' is so in relation both to 'young' and 'old', in the same way that an element which is 'relatively heavy' is so in relation both to what is light absolutely and to what is heavy absolutely.

But the two usages are not therefore identical.

1. An element which is 'relatively light' or 'relatively heavy' in Aristotle's sense must be so in relation to an element of another kind.
2. But an element which is 'comparatively heavy' or 'comparatively light' need be so only in relation to a larger or smaller quantity of the same element. Thus a quantity of water which is 'comparatively heavy' or 'comparatively light' need be so only in relation to a larger or smaller quantity of water.²

¹ This is exemplified by the use of κουφότερος in the passage already quoted, *De caelo* iv 4, 311a15–29.

² I shall argue in my essay on Aristotle that the more ordinary intensive use of the comparative may or may not denote an element which has relative weight in Aristotle's sense (air is lighter than water, but fire is also lighter than air; water is heavier than air, but earth is also heavier than water).

There will therefore be two reasons why the colloquial or non-intensive use of the comparative is not simply identical with Aristotle's conception of relative

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Conclusion

(i)

Thus at one time or another Cherniss has confused the distinction between absolutely heavy and relatively heavy, in Aristotle's sense of those terms, with variously:

1. The distinction between the simple positive and comparative, 'heavy' and 'heavier'.
2. The distinction between maximum heaviness and degrees of heaviness.
3. The distinction between 'heavy' (or 'light') and 'comparatively heavy' (or 'comparatively light').

(ii)

These confusions make it deceptively easy for βαρύτερον to take on the meaning of 'relatively heavy'.

1. On the first count, an atom can be reckoned as 'relatively heavy' simply because it is heavier than, or 'in relation to', another.
2. The confusion between absolute and maximum weight will again allow atoms with different degrees of heaviness to be automatically designated as 'relatively heavy'.
3. The colloquial use of a comparative such as νεώτερος is taken to justify this translation even outside the context of absolute heaviness.

(iii)

The confusion is not then at an end.

1. 'Relatively heavy' acts as a stepping stone to the superficially similar sounding 'relative weight'.

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weight. (1) The non-intensive use of the comparative will represent relative weight, only if the comparison lies between elements of a different kind. (2) Even so, Aristotle's conception of relative weight is not designated exclusively by this use of the comparative.

2. This translation can then mean *either* that 'each atom is heavier than some atoms and is lighter than others' *or* that 'each atom is relatively heavy when compared with any other'.

The *former* interpretation does not follow from the comparison that Cherniss offers with τὸ κουφότερον, an expression which he has in any case misunderstood. The *latter* interpretation makes nonsense in itself, and in particular it controverts Aristotle's whole theory of the distinction between relative and absolute weight.

§ 3—

Weight and Temperature

I return therefore to the passage which I transcribed at the beginning of this chapter, from the *De generatione et corruptione*. In that passage, the true interpretation of βαρύτερον, I suggest, is indicated partly by the association of atoms with absolute weight which we find in the *De caelo*, and which I have already analysed in my first chapter, and more immediately by the account of temperature, which weight is intended to establish and exemplify.

In an argument preceding the introduction of weight, Aristotle claims that heat is 'handed out' to round atoms, and that therefore the opposite of heat, which is cold, should 'belong' to some other shape of atom (i 8, 326a3–6). So much, at least in the short term, is clear enough. But why does Aristotle, a moment or two later (326a9–11), seek to argue from the admission that an atom is 'heavier' to the claim that an atom must therefore also be 'hotter'?

(i)

Aristotle does not think that heavy and light can act or be acted upon, a restriction which does not apply to differences of temperature, *De gen. et corr.* ii 2, 329b18–26: ξηρόν καὶ ὕγρὸν τὰ μὲν τῷ ποιητικῷ εἶναι τὰ δὲ τῷ παθητικῷ λέγεται.

'Oppositions which fall within the domain of touch are these: hot and cold, dry and wet, heavy and light . . .

'Of these, heavy and light are neither active nor passive, in so far as they are said <to be what they are>, not in virtue of their acting upon something else, nor in virtue of their being acted upon by something else . . .

'Hot and cold, by contrast, and dry and wet, are distinguished as such by their ability to act, or to be acted upon.'¹

From this difference, it follows that Aristotle cannot conclude his argument by asserting that 'what is less heavy cannot escape being acted upon by what is more so'. Weight has to act as a prelude to temperature. The argument is that if the atoms can be characterised individually as θερμότερον. The argument can then happily conclude that 'what is less hot cannot escape being acted upon by what is more so'. From this it follows that the atoms are not inactive or impassible.

(ii)

Philoponus betrays pretty clearly that he has missed the point of Aristotle's distinction between weight and heat when he seeks to conclude of both jointly, *De gen. et corr.* 167.15–16: θερμότεραι

¹ There are other and more subtle ways of expressing this difference, but the simplest consideration is that if a lump of lead falls on my foot it crushes it, and in that sense 'acts' upon it, but it does not make my foot any heavier, whereas hot and cold or wet and dry 'act' upon something by making it share in their own qualities.

If *per contra* we think of addition or admixture then it will of course be possible to assimilate heavy and light to hot and cold, wet and dry, as Plotinus does at one point: 'what is light makes things light, by its addition <to them> and by its presence <in them>, and <similarly> what is heavy makes things heavy' (*Enn.* iv 7 [2] 4.26–7). But this idea would not match the context in the *De generatione et corruptione*. Aristotle believes that for there to be a change of weight in any other than a merely incidental sense there would have to be a change of substance. Thus lead, added to another substance, would make that substance 'heavier', but in a merely incidental sense; Aristotle does not believe that the addition of lead would effect any real change in the second substance, nor therefore that either substance would have 'acted' or 'been acted upon'. The change would be a change in composite weight, not a change in elemental weight.

δὲ οὔσαι καὶ βαρύτεραι (sc. αἱ ἄτομοι) πῶς οἶαί τε μὴ ποιεῖν καὶ πάσχειν εἰς ἀλλήλας

'If atoms are to be hotter and heavier, how is it that they are able to refrain from acting upon each other, and from being acted upon by each other?'

Indeed it is, I think, largely because they fail to appreciate the distinction in Aristotle's philosophy between the inactivity and the activity respectively of extremes of weight and extremes of temperature, and therefore the need for the conclusion of the argument to be expressed in terms of temperature, that Cherniss and Joachim, as well as Philoponus, all in one way or another attempt to make the temperature of the atoms precisely comparable to their weight (in all respects except, as I shall suggest, the one which really helps): Cherniss by supposing that 'each and every atom must have relative heat in comparison with any other'; Philoponus and Joachim because they suppose that the larger an atom is, the hotter it will be.¹

Neither interpretation, it seems to me, properly answers to Aristotle's preoccupation in this passage.

1. Aristotle's argument does not require that 'each and every atom' should be hotter, or should have 'relative heat'. In the argument immediately preceding the conjunction of weight and of temperature, Aristotle clearly limits the possession of heat to spherical atoms, 326a3–5: περιφερεῖ σχήματι τὸ θερμόν. It is therefore either an oversight, or excessively restrictive, when Cherniss complains against Joachim and Philoponus, that 'there is no mention' by Aristotle 'of spherical atoms'.²

The idea that spherical atoms (alone) are hot is clearly intended to be carried over from one argument to the next. The example of weight is meant to show, not that 'each and every atom' is hot or hotter, but that atoms which are individually θερμότερον.

¹ Cherniss, *ACP* 98 n.413 (the last word in the third line of this note should be 'hotter' and not 'heavier'). Philoponus, *De gen. et corr.* 167.11–17, esp. 13–14. Joachim, in the notes to his edition, 165–7.

² *ACP* 98 n.413.

2. At the same time, no theory of *how* one atom is hotter than another need be implied in, or can be inferred from, this passage. Aristotle's argument does not imply that larger spherical atoms are hotter than smaller ones, nor that 'Aristotle thought a large sphere more spherical than a smaller one'.¹

The truth is that only two genuine pieces of atomic theory are introduced by Aristotle into this argument.

1. Heat is 'handed out to' (more strictly, is the product of) spherical atoms.

2. Each atom is βαρύτερον κατὰ τὴν ὑποροχὴν.

From these two pieces of information Aristotle seeks to draw the inference that atoms which are individually θερμότερον: so that he can then draw the polemical conclusion that what is less hot cannot escape being acted upon by what is more so, a conclusion which he sees as controverting Democritus' claim that the atoms are inactive and impassible.

In the course of this reasoning, Aristotle gives no sign that he intends to draw the comparison between weight and temperature any tighter than is needed to show that if the atoms have degrees of weight so they, or some of them, must have degrees of temperature. There need be no implication that *'each and every'* atom must have relative heat' (Cherniss, my italics), nor that there is a preponderancy in virtue of which the atoms are heavier which is the same as the preponderancy in virtue of which they are hotter (Philoponus and Joachim).

Indeed the reason why ὑπεροχὴ is probably intended as no more than a passing reminder of the manner in which Democritus attributed

¹ I quote Cherniss' attempt to trivialise Joachim's argument, *ACP* 98 n.413. Verdenius and Waszink, *Comments* 43, also suppose that 'the attribution of heat cannot be restricted to a special class of atoms', with the idea therefore that there should be 'differences of heat among all atoms'. But Aristotle's argument will be sufficiently cogent if he can show that some atoms are open to action and passion; he does not—in the immediate argument—have to show that all atoms are subject to alteration in respect of an opposition of temperature.

weight, and differences of weight, to the atoms. For nothing more is relevant to Aristotle's argument than Democritus' claim that the atoms are characterised by differences or degrees of weight. This Aristotle accounts sufficient justification for his conclusion that if an atom is θερμότερον. The way in which the atoms are characterised by degrees of weight is irrelevant to Aristotle's argument, since it is the fact only, and not the cause or accompaniment, of degrees of weight which needs to be carried over into the realm of temperature.¹

(iii)

At the same time, without wishing to expand Aristotle's argument unduly, the one comparison between weight and temperature which can, I think, validly be drawn from Aristotle's argument is one which Cherniss and Joachim fail to draw.

In order to avoid Dyroff's difficulty, I think it is fair to claim that βαρύτερον κατὰ τὴν ὑπεροχὴν is intended to be, or at least

¹ I would therefore construe Aristotle's argument at this point (326a10–11) as containing the ellipse: . . . ὥστε δῆλον ὅτι <εἰ θερμόν> καὶ θερμότερον.

Cherniss, *ACP* 98 n.413, seeks to support his interpretation (that 'each and every atom must have relative heat') by quoting an argument from the *De caelo* where Aristotle claims, iii 8, 307a13–15: ἔτι δ' εἰ θερμαίνει καὶ καίει τὸ πῦρ διὰ τὰς γωνίας, ἅπαντα ἔσται τὰ στοιχεῖα θερμαντικά, μᾶλλον δ' ἴσως ἕτερον ἑτέρου.

But this argument is intended as a *reductio ad absurdum* of the atomic theory. Aristotle concludes, 307a18–19:

δῆλον ὅτι καὶ τὸ πῦρ καὶ ἕκαστον τῶν στοιχείων ἐν μὲν τῷ ἄλλοτρίῳ τόπῳ σφαῖρα ἔσται ἢ πυραμὶς, ἐν δὲ τῷ οἰκείῳ κύβος. In my opinion, it would not be at all typical of Aristotle's style of polemic to store up this kind of criticism from one context to the next.

Here and throughout, in writing of 'degrees' of heat, as in writing of 'differences or degrees' of weight or of heaviness (*cf.* p.52 above), I do not of course mean that Aristotle has any notion of a measured scale for the comparison of (what he supposes to be) qualities; I use the word therefore in a looser and more general way, to mean a non-quantitative comparison of intensities—though of course even this formulation is anachronistic in the presuppositions which it betrays. As always, the vocabulary we use for the description of ancient science or of ancient philosophy is riddled with anachronisms, and yet to be too zealous in rooting them out leads to an impossible pedantry. (The non-quantitative use of the word 'degree' is in fact dated to Middle English by the *Oxford English Dictionary*; but in the context of weight and of temperature this earlier sense of the word is of course likely to be displaced for the modern reader by the later technical and scientific usage.)

leaves room for immediate interpretation as, one half of an implied antithesis.¹

The obvious pair to *κατὰ τὴν ὑπεροχήν* in itself actually means, or is an abbreviation of, the dual expression.

The equivalent pair to *κουφότερον*, so that the completed form of the implied antithesis would run:

'Each atom is heavier <or lighter> in virtue of its preponderance <or deficiency> in relation to another'.

In that case, Aristotle's account of the Atomists in the *De generatione et corruptione* will be almost precisely parallel to the account he gives, in the *De caelo*, of Plato. I have already quoted the sentence where Aristotle writes, of Plato's compound bodies, that 'each one is heavier depending upon its preponderance of equal parts'.² This sentence follows almost directly the double formulation that, on Plato's theory, 'a body which is constituted from a larger number of identical parts is heavier, while one which is constituted from a smaller number of like parts is lighter', iv 2, 308b5–6: *ἐξ ἐλαττόνων*.

But in the parallel account of temperature, in the *De generatione et corruptione*, Aristotle treats not of hot and cold, but of what is more hot, or less so, i 8, 326a11–12: *οἷον ὑπὸ τοῦ πολὺ ὑπερβάλλον-τος θερμοῦ τὸ ἥρέμα θερμόν*.

I think that we should therefore suppose that in fact the implied antithesis in Aristotle's mind is that:

'Each atom is more heavy <or less so> in virtue of its preponderance <or deficiency> in relation to another.'

¹ This will be so even if, or more especially if, we adopt some version of the English formula, 'the more an atom is x, the more it will be y' (cf. Guthrie's translation, p.46 above). In translating thus, we at once imply that 'the less it is x, the less it will be y'. Dyroff's interpretation has been noted p.42 above.

² *De caelo* iv 2, 308b9, pp.45–6 above.

'More Heavy or Less So'

(i)

A critic may object that this is a distinction without a difference: what is less heavy must be lighter.

But this is not in fact so for Aristotle.

1. Where there are two elements which both have heaviness Aristotle will grant that the one is lighter, or 'more nearly light', than the other, *De caelo* iv 2, 309b6–8: . . .

κουφότερον, οἷον γῆς ὕδωρ. This is because if it finds itself in the place belonging to earth, water will rise.

2. Of earth which is absolutely heavy, I think it is clear, Aristotle would allow only that a smaller piece could be less heavy than a larger piece, not that it could be in any way light or lighter, since there is never any circumstance in which any portion of earth would travel naturally upwards.¹

The distinction between 'heavier or lighter' and 'more heavy or less so' is therefore for Aristotle a real one. It is also a distinction which will apply to the present context if, as in the passages which I have quoted from the *De caelo* in my first chapter, the distinction between void and solid, in the atomic theory, is taken to match the distinction between absolutely light and absolutely heavy. For once the atoms are thought of as having absolute heaviness, as earth has in Aristotle's own system, then it will be natural, and indeed necessary, for the differences of weight between them to be expressed in terms not of heavy and light, but of more heavy or less heavy.²

¹ The two distinctions, that between 'lighter' and 'more nearly light', and that between 'lighter' and 'less heavy', are explored in my third essay.

² It may be objected that by the same reasoning Aristotle should not refer to Plato's triangles as producing a body which is heavier or 'lighter', as he does in the passage I have just quoted (*De caelo* iv 2, 308b5–6), or at least that this is inconsistent with my supposition that Plato's triangles, like Democritus' atoms, are thought of by Aristotle as approximating to the possession of absolute weight (cf. p.38 n.1 above). But here, as later in the passage (308b22, b25), κουφότερον is introduced only as marking Plato's claim. The argument of the

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(ii)

A second difficulty is to know whether in fact Aristotle writes of what is more hot or less so, or whether he writes of hot and of cold.

For the text I have transcribed above, which is that adopted by Joachim and by Mugler, relies on only one manuscript (F), supported by Philoponus and by Asulanus' Latin translation. The other four primary manuscripts (EHJL) have τὸ ἥρεμα ψυχρόν.¹

Cherniss claims that with his interpretation of the passage 'it is no longer necessary to change the MSS from ψυχρόν to θερμόν'.²

But even if we overlook the exaggeration of calling a majority of the manuscripts 'the' manuscripts, *prima facie* there would seem no more reason for θερμότερον if it means 'relatively hot' than if it means 'hotter'.

Possibly, by his references to relative heat, Cherniss has entangled himself in the same ambiguity and equivocation that we have already uncovered in his use of the expression 'relative weight': 'relative heat' is introduced as a translation of θερμότερον, but is then transposed to mean that 'each and every atom must have relative heat', in the sense that it will be both hotter than some atoms and colder than others.

However, even if we discount Cherniss' claim, we may still wish to argue that precisely because there is no technical distinction in Aristotle's philosophy between relative heat and absolute heat there can therefore be no real distinction between being less hot and being more nearly cold: the difference between τὸ ἥρεμα

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passage (308b3–28) is precisely that the triangles' behaviour is inconsistent with Plato's description of them, or of their products, as 'lighter' in the positive sense which that term has in Aristotle's own theory. It is the conclusion to an equivalent criticism which I suggest is implicit in Aristotle's use of βαρύτερον in his account of Democritus' theory in the *De generatione et corruptione*.

¹ I take the manuscript readings from Joachim's edition (Oxford, 1922). For Asulanus' translation, here as below p.75, see the Bibliography. The peculiar position of F (codex Laurentianus 87.7 saec. xiv) in the manuscript tradition is characterised as follows by Moraux, in his Introduction to the Budé edn of the *De caelo* clxxx: 'Si, dans la plupart des cas, F ne présente rien de bien original, il lui arrive d'offrir, çà et là, des leçons d'un grand intérêt, qui lui sont particulières. Elles peuvent être issues de conjectures ou avoir été inspirées par les commentateurs, mais il n'est pas exclu qu'un ancêtre de F ait eu accès, Dieu sait comment, à une tradition ancienne étrangère à *a* et à *b* (the two main families of manuscripts, headed respectively by E and by J).

² *ACP* 99 n.414.

τὸ ἡρέμα θερμόν, we might then claim, is fairly arbitrary.

But in fact it strengthens Aristotle's immediate argument considerably if it is cast solely in terms of degrees of hotness, i.e. of what is more hot or less so, and not in terms of what is hotter or colder. For in the first argument of this series (326a3–6) Aristotle claims that the Atomists themselves went no further than to characterise spherical atoms as hot; to which Aristotle adds by way of criticism that the opposite of hot, which is cold, should 'belong' to some other shape of atom.

If therefore Aristotle introduces hot and cold into the present argument, he will detract from its cogency because he will be founding his new conclusion not on some admitted, or alleged, feature of the Atomists' own theory, but on a conclusion that comes merely from his attempted refutation of the theory.¹

(iii)

Indeed it is the desire to express the argument solely in terms of what is more hot or less so, and not in terms of hot and cold, that explains, I would suggest, Aristotle's conjunction of weight and temperature.

For the preceding argument, the second of the series, contains precisely the assertion that hot and cold do belong to the atoms, 326a6–7:

ἄτοπον δὲ καὶ εἰ ταῦτα μὲν ὑπάρχει, λέγω δὲ θερμότης καὶ ψυχρότης... . If therefore Aristotle had wished to conclude simply that what is hot must act upon what is cold, he could presumably have done so directly, without the mediation of weight.

The account of differences in weight is introduced precisely in order to expand the notion of heat simply (θερμόν) to that of

¹ I have already noted that there is in fact a sense in which, in the *De generatione et corruptione*, Aristotle speaks of what is 'absolutely' or 'altogether' hot (ii 7, 334b8–20, cf. p.52 n.3 above). But it is nonetheless true to say, I believe, that in Aristotle's philosophy there is no distinction between absolute and relative heat of the kind that there is between absolute and relative weight. The antithesis to what is absolutely hot or absolutely cold lies in a mere mixture of hot and cold: there is no distinction between relative and comparative heat, in the way that Aristotle attempts to distinguish between relative and comparative weight. I return to this point in the opening chapter of my fourth essay; see also the footnote following this.

degrees of heat (θερμότερον), so that action and passion can be attributed not to cold and heat jointly, but to one half only of that opposition, namely heat, because Aristotle believes that the Atomists themselves have admitted heat as belonging to the atoms.

Thus it is apparent, I would claim, not only that βαρύτερον, is in fact a highly desirable, if not an essential, feature of Aristotle's argument.

1. The former distinction alone answers to Aristotle's critique in the *De caelo* of the atoms as heavy absolutely, in the sense that they move consistently downwards.
2. That same distinction alone provides the proper analogy for temperature, if the present argument is to stand independently of the argument which precedes it.¹

¹ From this it follows that the parallel that I am arguing for between 'more heavy or less so' and between 'more hot or less so' springs not from Aristotle's own theory of temperature, but from the polemical consideration that I have remarked upon. For in Aristotle's own theory what is less hot will be more nearly cold, as distinct from the comparison between different portions of earth, which may be more heavy or less so, but none of which will ever be in any positive sense light or lighter.

The comparison of weight with temperature does not follow therefore from any intrinsic similarity between weight and temperature in Aristotle's own theory, as Cherniss appears to suppose, but from what Aristotle sees as the limitation in the Atomists' theory, in which hotness is aligned with, or explained by, round atoms, but in which no equivalent explanation is given of coldness, nor even of degrees of hotness. Thus the conjunction of weight and temperature arises accidentally, as it were, from the purposes of Aristotle's present criticism. It is not a consequence of a distinction in Aristotle's own philosophy between 'absolute' and 'relative' heat.

I have written here of two 'independent' arguments; in the final section of this chapter, pp.69–76 below, I shall seek to show that the arguments are linked, in so far as the *premiss* to the argument from weight corresponds to part of the *conclusion* to the preceding argument.

Verdenius and Waszink endorse Cherniss' choice of τὸ ἥρεμα θερμόν (326a12) is needed precisely because the interaction is supposed to lie within one half only of the opposition. An opposition between

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Aristotle's Argument

Thus in order to appreciate the genesis, and the construction, of Aristotle's argument, it is necessary to grasp the rather subtle relation between the atomic theories of weight and of temperature, as Aristotle presents them to us, and the manner in which Aristotle employs these two theories, for the purposes of his attack on the whole notion of Atomism, and in particular on the notion of the atoms' being inactive and impassible.

(i)

The atomic theory of temperature, at least as presented by Aristotle, has two limitations.

1. The Atomists do not explain how there can be degrees of heat. Thus heat is explained by, or is somehow, according to Aristotle, identified with, spherical atoms. But there is no immediate reason to suppose, nor any obviously convenient way of arguing, that a larger spherical atom, for example, will be hotter than a smaller one, or *vice versa*, or that one atom could be hotter because in some way 'more spherical' than another.
2. The Atomists explained heat alone in terms of shape. They did not, apparently, give an equivalent explanation of cold.¹

(ii)

At the same time, there are two elements in Aristotle's own thinking which are essential to the form of his argument.

1. The opposition of hot and cold is open to action and passion, but not so the opposition of heavy and light.

(footnote continued from previous page)

hot and cold would be sufficient to require an interaction, without more ado, so to speak. It is, I would suggest, because the larger implications which I have sought to outline require the interaction to be limited to what is hot that Aristotle needs to emphasise the difference between the two extremes of what is hot only.

¹ For this second point see *De caelo* iii 8, 306b29ff., esp. 307b5–9; cf. pp.71–3 below.

2. Whatever has absolute weight can be described only as 'more heavy or less so' (if it has absolute heaviness) or as 'more light or less so' (if it has absolute lightness), but the parts of a single element which has absolute weight (whether heaviness or lightness) cannot be described as being 'heavier or lighter'.

(iii)

From the *first* limitation in the atomic theory of temperature, and from the *first* element in Aristotle's own thinking, it follows that weight and temperature have each an advantage, for the purposes of Aristotle's argument, and a disadvantage; or a virtue and a defect.

1. Weight has the *virtue* of being expressed by Democritus, or as being easily expressible on his theory, in terms of degrees of weight, or degrees of heaviness; but it has the *defect* of not being open to action and passion.
2. Temperature has the *virtue* of being open to action and passion; but it has the *defect* that Democritus' theory of heat does not in itself lead to there being degrees of temperature, or degrees of hotness.

Aristotle as it were cross-fertilises, or cross-matches, weight and temperature, so that the virtues are joined, and the defects cancel each other out. He argues that because one atom is θερμότερον.

Temperature now has the two virtues:

1. that it is open to action and passion: this is the virtue that it had already in Aristotle's theory.
2. that there are degrees of temperature: this is the virtue that temperature now acquires from the comparison with weight.

(iv)

The *second* limitation in the atomic theory of temperature

requires that θερμότερον at this point must represent not what is hotter *or colder*, but what is more hot *or less hot*.

This restriction, however, answers neatly to the *second* element in Aristotle's own thinking, namely to his conception of the atoms, in the *De caelo*, as approximating to the possession of absolute weight, so that degrees of weight are properly expressed not as differences between what is heavier *or lighter*, but as differences between what is more heavy *or less heavy*.

Thus the restriction in the atomic theory of temperature answers precisely to the restriction which Aristotle's own conception of absolute weight introduces into the atomic theory of weight. In either case, degrees of temperature and degrees of weight are expressed in terms of one half only of the opposition between hot and cold and between heavy and light.

1. One atom is more heavy, or is less heavy, than another.
2. One atom (it is argued) is more hot, or is less hot, than another.

(v)

Thus the final form of Aristotle's argument is that:

'Since one atom is more heavy, or is less heavy, than another, so too if an atom is hot it must be more hot, or less hot, than another.'

This enables Aristotle to conclude that an atom which is more hot must act upon one which is less so, and therefore that the atoms are not inactive or impassible.

§ 4—

The Sequence of Arguments

The 'Denial' of Weight

There remains a difficulty in the precise turn of thought at καίτοι ... γε.

Presumably pursuant upon his supposition that the atoms cannot be accounted as having 'real' weight, Cherniss writes that:

'Democritus has paradoxically denied weight to the atoms although he has endowed some atoms with heat. Yet, having denied that the atoms are heavy or light, he asserts that in comparison with one another they have *relative* weight.'¹

This is inaccurate at once in its reproduction of the content of what is said, and in its attribution of the different parts of what is said.

There is no denial by Democritus that the atoms are heavy or light. Aristotle's first point is that:

'It *would* be strange (ἄτοπον δὲ καὶ σ. ἢν οἱ εἴη) if heavy *and* light are not going to belong to the atoms.'

Aristotle then adds:

'And yet Democritus *does* say (βαρύτερον) .

Thus the lack of heaviness and lightness, as an extreme form of the atoms' lack of sensible qualities, is advanced not by Democritus, but by Aristotle, and even so only as a potential absurdity. Democritus is introduced as in fact mitigating that absurdity, by his admission that each atom is βαρύτερον .

Thesis and Refutation

However, to see this point in perspective, we need to look back to the passage which I quoted at the beginning of this chapter, to see Aristotle's sequence of argument as a whole.

(i)

Aristotle first states the thesis, or the pair of theses, which he intends to controvert.

(1) No atom is capable of receiving any 'affection' (i 8, 325b36–326a1), and

(2) no atom is capable of producing any 'affection' (πάθους, 326a2–3).

¹ ACP 98 n.413, cf. 211 n.253, quoted pp.16–17 above.

The *first* thesis Aristotle claims to establish from the principle that for the Atomists affection or alteration can take place only through the presence of void (326a1–2). The implication is that void is excluded from the 'indivisibles'. Not only is this obvious enough in itself, 'void' and 'contiguity' (διαίρετόν) in the atomic theory (325b29–33), and as excluded therefore from the internal structure of the atoms.

The *second* thesis Aristotle does not seek to justify independently. But the justification for it is again obvious in the light of Aristotle's preceding analysis, where he has sought to show that the primary moving cause may act without being acted upon, but that this is not possible for the proximate moving cause, which cannot act without itself being acted upon (cf. i 7, 324a24–b24).

'For example, the healing art produces health without being affected by the body that is brought to health, but food, when it produces an effect, is itself subject to an affection—it grows hot, or grows cold, or is affected in some other way, at the very time when it acts upon the body <which has ingested it>' (324a35–b3).

It follows therefore, for Aristotle, that if an atom cannot itself be 'affected' (the *first* thesis), then it is also incapable of acting as the proximate cause of an 'affection' (the *second* thesis).

(ii)

The remainder of the passage I have quoted (326a3–14) is most simply taken as a series of four related arguments designed to controvert the twin theses that Aristotle has attributed to the Atomists, and to do so by exploiting concessions which the Atomists have themselves made towards the notion of an 'affection' for the atoms.¹

Thus the first argument claims that if heat is to be attached ('handed out', cf. ἀποδοῦναι 326a4) to a round shape, then the opposite of heat, which is cold, should be attached to some other shape (i 8, 326a3–6).

¹ The 'four' arguments: i 8, 326a3–6, a6–8, a9–12, a13–14.

In the *De caelo* Aristotle develops a more elaborate argument against those who attempt to explain fire as a sphere or as a pyramid, the two views respectively of Democritus and of Plato (iii 8, 306b29ff., esp. 306b33, cf. *Tim.* 56A-C). In the *De caelo* Aristotle argues in particular that although hot and cold are 'opposite in their power' it is impossible to find a shape to assign to cold since 'what is assigned' would have to be opposite, and there is no opposite to a shape (307b5–8, again διὸ καὶ πάντες ἀπολείπειν αὐτὸ 307B8–9).

It is this conclusion, I would suggest, which explains the argument in the *De generatione et corruptione*: heat has been explained by round atoms, but there has been no equivalent explanation of cold.

(iii)

There is however a crucial difference between the *De caelo* and the *De generatione et corruptione*.

In the former treatise Aristotle argues in effect that there cannot be an equivalent explanation for cold, and that 'therefore' (διὸ καὶ) Plato and Democritus ('everyone') have 'omitted' this point.

By contrast, in the *De generatione et corruptione* Aristotle implies only the more particular point, that the Atomists have in fact failed to give an explanation of cold, and not that it is impossible for them to have done so. For the following argument, the *second* of the series, starts from the premiss that hot and cold could be regarded as both of them 'belonging' to the atoms, and seeks to demonstrate from this a fresh 'absurdity'. This at least I take to be the implication of the premiss, 326a6–7: ἄτοπον δὲ καὶ εἰ ταῦτα μὲν ὑπάρχει.

This does not of course mean that there is any real inconsistency between the two arguments, that of the *De caelo* and that of the *De generatione et corruptione*. It is however essential to appreciate the difference between the two arguments.

1. In the *De caelo*, Aristotle argues that the Atomists and Plato have not, and cannot, provide an explanation of coldness to match their explanation of heat.

2. In the *De generatione et corruptione*, Aristotle again implies that the Atomists have not provided an explanation of coldness; but his point is now that *even if* (by some unspecified means) they were able to do so their theory would lead to fresh absurdities.

(iv)

This difference is essential to an appreciation of the sequence of thought in the *De generatione et corruptione*.

Aristotle's *second* argument is that if hot and cold are to 'belong' to the atoms then it is odd that other pairs of opposites should not also 'belong' (326a6–8, ὑπάρχει ... ὑπάρξει). The additional oppositions which Aristotle specifies are heavy and light, hard and soft.

The point to note is that just as the conclusion to the *first* argument of the series ('there should be a cold, as well as a hot, atom') had been employed as a premiss to the *second* argument ('if hot and cold do belong to the atoms, then other pairs of opposites should belong as well'), so now parts of the conclusion to the *second* argument are used as a premiss not for one, but for two further arguments, which are attached successively to the opposition of weight (326a9–12: the *third* argument) and of density (326a13–14: the *fourth* argument).

This subordination is perhaps most clearly seen in the relation of the *second* argument to the *fourth*. The *second* argument concludes that hardness and softness should also belong to the atoms, if hot and cold are to belong (326a6–8). The *fourth* argument claims that if an atom is hard, it will also be soft, but that what is soft is defined by its passivity, since what is soft is what is yielding (326a13–14).

Thus the *fourth* argument takes as its premiss part of one half of the conclusion to the *second* argument, in much the way that the *second* argument had taken as its premiss the conclusion to the *first* argument.

If the atoms are to be hot they should be cold as well (the conclusion to the *first* argument); suppose that they could be both hot and cold . . . (the premiss to the *second* argument).

The atoms would then have to be hard and soft (half of

the conclusion to the *second* argument); but if an atom is hard . . . (the premiss to the *fourth* argument).

The relation between the *second* argument and the *fourth* is, I believe, exactly paralleled in the relation between the *second* argument and the *third*:

The atoms would have to be heavy and light (the other half of the conclusion to the *second* argument); but an atom which is heavier . . . (the initial premiss to the *third* argument).

(v)

The parallel with density helps, I would suggest, to explain the intricacy of the argument from weight.

The conclusion to the *second* argument, that both hardness and softness should belong to the atoms, leaves itself open to the objection that the Atomists would not have denied that the atoms were hard, indeed that hardness or 'solidity' had been intended precisely as a means of rendering the atoms immune to division.¹

It is, I would suggest, in order to circumvent this objection that Aristotle attempts, so to speak, to shift the conclusion of his argument from hard and soft taken together in the *second* argument, to the more specific conclusion, in the *fourth* argument, that an atom must be soft, and cannot therefore be impassible.

A similar, but more complex, preoccupation underlies the *third* argument. The other half of the conclusion to the *second* argument, that the atoms should have heaviness and lightness, is again open to the objection that the Atomists admitted that one atom was heavier than another, and that in any case the possession of weight, on Aristotle's own theory, does not directly entail action or passion.²

Again therefore Aristotle seeks to reinforce the conclusion to the *second* argument, but the way in which he does so, in the *third* argument, is more complex than it is in the *fourth*. For since—in Aristotle's own theory—neither heaviness nor lightness will admit

¹ The first point I take to be obvious. For the second point see the passages quoted below p.245 n.1.

² For this second point see the passage quoted above, pp.57–8, *De gen. et corr.* ii 2, 329b18–26.

of action or passion in any direct sense Aristotle cannot simply shift the object of his demonstration to one member in the opposition of heavy and light, as he will do, for the opposition of density, in the *fourth* argument. Instead Aristotle uses the comparison of heaviness in the atoms to establish a comparison of temperature, in the way that I have delineated, so as to arrive at the conclusion, not that an atom which is heavier will act upon one which is less so, but that an atom which is more hot will act upon one which is less so.

(vi)

I turn therefore to the expression at the end of Aristotle's opening statement of the Atomists' twin theses, the words: σκληρόν (EL). Once again I have preferred the reading in Asulanus' Latin translation: *calidum . . . frigidum*.

Obviously, the alteration has to be conjectural. I have adopted it, because it conforms to the sequence of thought in the remainder of the passage, whereby the premiss to each argument is picked up from the conclusion to the preceding argument. This will also be the case for the *first* argument, if Aristotle has specified the opposition of hot and cold as the illustration of the thesis which he attributes to the Atomists.

The atoms cannot be hot or cold (326a3: the example to the thesis); and yet heat is attached to a round atom . . . (326a3–5: the premiss to the *first* argument).

Indeed, on this reconstruction the relation between the *example* to the thesis and the premiss to the *first* argument will correspond precisely to the relation between the conclusion to the *second* argument and the premiss to the *third* argument: in each case, Aristotle uses the formula καίτοι βαρύτερόν γε ... φησιν, 326a9).

I conclude that the structure of the four arguments may be presented, in a very simplified form, as follows:

Thesis: the atoms are inactive and impassible.

Example: the atoms cannot be *hot* or cold.

First argument

Premiss: if a round atom is *hot*

Conclusion: what shape belongs to a cold atom?

Second argument

Premiss: if the atoms are hot and cold

Conclusion: they should also be *heavy* and light and *hard* and soft.

Third argument

Premiss: but an atom which is *heavier*

Conclusion: would lead to an atom which was hotter. But if atoms have differences of heat . . .

Fourth argument

Premiss: if an atom is *hard*

Conclusion: there must also be a soft atom. But what is soft . . .

(vii)

Briefly therefore I return to Cherniss' understanding of the passage: the belief that Democritus is here accused of inconsistency.

The point will perhaps be plainer if we consider again the two instances of καίτοι ... γέ, used to introduce the *first* and *third* arguments (326a3–4 and 326a9). In neither case is Aristotle's meaning that Democritus denies that the atoms are hot and cold, or heavy and light, and therefore that Democritus is inconsistent in asserting that they may be hot or heavy. In both cases, Aristotle's point is that Democritus' theory *should* exclude the opposition of temperature and of weight, but that Democritus does make (some) allowance for one member of either opposition: a round atom is hot; each atom is heavier. From these two admissions Aristotle then seeks to derive the absurdity, firstly that there should be a shape for a cold atom as well as for a hot atom, and secondly that the admission of an atom which is more heavy <or

less so> would require the admission of an atom which was more hot or less so.

If we consider all three oppositions, of temperature, weight and density, then in each case Aristotle's denial that the atoms can be hot *and* cold (326a3), or have heaviness *and* lightness (326a7–8), or have hardness *and* softness (326a7–8), is presented as Aristotle's own conception of a consequence which the Atomists should accept, while the association which Aristotle, directly or by implication, attributes to the Atomists themselves is in each case restricted to one member only of the opposition: namely that the atoms are, or may be associated with, what is hot (326a3–5), or heavy (326a9–10) or hard (326a13).¹

Conclusion

I therefore paraphrase our first passage as follows:²

Thesis

'Since <on the Atomists' own theory> the <atoms or> indivisibles would be able to undergo change or alteration only through the mediation of void <and since at the same

¹ At both 326a3 and 9 (the *first* and *third* arguments respectively) I adopt the adversative sense of μή ὑπάρξει 326a8).

It should be noted that in this combination of particles the meaning of καί is emphatic, not restrictive. There is no implication that an atom is 'at least heavier <but not heavy absolutely>'. The meaning is: 'and yet—on *this* point—heaviness—Democritus does say . . .'. See Denniston, *Greek particles* 564, cf. 120–1. It is however difficult to convey this inflexion, even in a paraphrase: as often, written English simply does not provide for a precise rendering of the nuance of the Greek particles.

² *De gen. et corr.* i 8, 325b36–326a14, quoted pp.41–2 above. On the nature of these English versions—paraphrases and not translations—see the warning at the head of the Index Locorum.

time each atom is by definition plenum and not void>, therefore the Atomists must maintain that each of the <atoms or> indivisibles is incapable of *undergoing* change or alteration of any kind and that <by the same token> it is <equally> incapable of *producing* any kind of qualitative change or alteration <in another atom or indeed in anything else at all>.

Example

'For <example> it is <or should be> impossible <for any one of the atoms> to be hot or cold. <For in that case the atoms would be exhibiting a certain qualitative affection, which would require them to be capable of causing, or of undergoing, change or alteration of the kind entailed by that affection.>

Refutation:

First argument

'And yet the Atomists do hand out heat <as it were> to the round shape <of atom>.

'But to stop there is illogical. It must follow that the opposite <of heat which is> cold does equally belong to some other shape <of atom>.

Second argument

'<But the absurdity does not stop there.> It would be equally odd if these things do indeed belong <to the atoms>, I mean coldness and heat, while at the same time (μέν ... δέ ...) heaviness and lightness, and hardness and softness, are not going to <be counted as> belong<ing>.

Third argument

'And yet the fact is that Democritus does say that each one of the <atoms or> indivisibles is more heavy <or less so than another> in virtue of its preponderance <or deficiency>.

'Hence by the same token (ὥστε ... καὶ) an atom <which is hot> must clearly be more hot <or less so>.

'But once the atoms are characterised thus <by degrees of hotness in the same way as by degrees of heaviness>, they cannot escape being affected by one another.

'For example, what is mildly hot is not going to escape being affected by something overwhelmingly hotter.

Fourth argument

'And there is an <equivalent> objection <in the case of density>: if an atom is going to be hard <as one might expect it to be, and as the Atomists themselves obviously imagined that it would be>, then <it must be> soft as well: <for it is impossible to have one opposite from a pair of contraries without the other>.

'But what is soft is at once defined as such by its ability to undergo a certain kind of change: for 'soft' is <precisely> what is capable of being compressed.

'<Once again therefore it is impossible in fact for the atom not be to subject to some form of change or alteration.>¹

¹ For a final note on the meaning of ὑπεροχή—looking back from the vantage point of the parallel passage in the *De caelo*—see below p.100.

Chapter Three— Aristotle 'De Caelo'

§ 1— Individual Atoms

(i)

The second Aristotelean passage from which we may hope to recover Democritus' theory is at once more complex, at least in its immediate context, and more informative. It occurs in Aristotle's primary analysis of weight in book four of the *De caelo*.

We learn more here: both because Aristotle is not now concerned with the atomic theory of weight only in passing, as one step in an argument whose interest is focussed elsewhere, as was the case in the *De generatione et corruptione*; and probably also because Aristotle is not at this point concerned with disparagement of the Atomists' theory, wrong though he thought that theory to be, but, initially at least, with its short term advantages vis-à-vis the theory of the *Timaeus*.

On the other hand, the fact that Aristotle's critique of the Atomists is still tied in at this point with his critique of the Platonic theory means that we still do not see the Atomists' theory full face on, as it were, as we shall do in Theophrastus, and that the interpretation of the passage still has to be handled delicately therefore.

(ii)

After criticising a considerably simplified version of the theory of weight advanced in the *Timaeus*, Aristotle continues as follows, iv 2, 308b28–309a11 (in part DK 68A60): συγκεῖσθαι τῶν πρώτων τὰ ἰσοβαρῆ· ἴσα γὰρ ἂν ᾖν τὸν ὄγκον. τὰ δὲ πρῶτα καὶ

τὸ πλεῖον ἐνυπάρχειν κενόν.

(iii)

Cherniss believes that the whole of this passage, and in particular the phrase, τὸ μείζον εἶναι βαρύτερον αὐτῶν, concerns compound bodies. He concludes:

'Consequently this passage, which is one of the two in which Aristotle is supposed to attribute weight to the atoms . . . says nothing of the matter.'¹

Professor Guthrie, who had not taken the passage this way in his translation of the *De caelo*, now agrees with Cherniss:

'I think Cherniss has shown conclusively . . . that these words refer to compounds. The immediately following τῶν δὲ συνθέτων makes this seem unnatural, but the whole of Aristotle's argument demands it, and it is not the first time that he has been caught out in careless or inelegant composition.'²

¹ *ACP* 211 n.253, cf. 97 n.412.

² *History* ii 403 n.2. Loeb edn of the *De caelo* (1939) 335. (The reference to Cherniss in Professor Guthrie's *History* should be corrected to conform to the footnote preceding this.)

John L. Stocks, in his translation of the *De caelo* in *The works of Aristotle translated into English* ii (Oxford, 1930), took the phrase to describe individual atoms, as Professor Guthrie had originally done. Other recent translators continue to take the passage in this way, for example Oddone Longo, in his edition and translation of the *De caelo* (Firenze, 1961) 263, and Moraux, Budé edn 139; but whether in ignorance of, or in disagreement with, Cherniss, one cannot tell.

The passage is admittedly somewhat complex, at least in its central portion, but a careful examination of thought and argument makes it reasonably clear, it seems to me, that on the contrary there is here a distinction between individual atoms and compound bodies, and a different theory of weight for each.

This will in fact prove to be precisely the same distinction, and the same two theories of weight, that we find in Theophrastus' *De sensibus*, in a passage which will be analysed later in this essay; but for the sake of clear exegesis it is, I think, advisable to start by analysing Aristotle's evidence independently.¹

Preliminary Analysis

(i)

The first part of Aristotle's argument is fairly straightforward.

The Platonists are those whose views have just been outlined (ἀρχαιότεροι ... καινότερος) prove to be the Atomists.

Aristotle's argument begins with a statement of fact (φαίνεται γάρ), which he presents as the starting-off point for the Atomists' speculations: of two bodies of different sizes, the smaller may be the heavier.

From this fact, Aristotle argues, on behalf of the Atomists as it were, that it is 'inadequate' (οὐκ ἱκανόν) for weight to be determined simply by the number of equal primary elements in a body, for in that case two bodies of the same weight would have the same number of primary elements, and they would therefore, if no other factor is introduced, have the same volume.

The implication of this is that any increase or diminution of weight could then be attained only by an increase or diminution of volume, so that the smaller body would always be the lighter, contrary to the fact noted at the outset, that of two bodies of different sizes the smaller may be the heavier.

The view which is 'inadequate' is that of the Platonists.

1. τοῖς δ' (sc. the Atom-

¹ *De sens.* 61–2, cf. ch.IV § 1, pp.115–31 below.

ists) διελεῖν.

2. What is 'inadequate', τῶν ἴσων μορίων βαρύτερον ἑκαστόν ἐστιν.¹

(ii)

Because Aristotle presents the Atomists' theory, with deliberate anachronism, as an advance upon Plato, he is led to turn aside at this point to add an additional refutation of the Platonic view. In so doing, he postpones the completion of his account of how the Atomists advanced from the inadequacy of the Platonic view to their own improvement upon it.

The primary bodies which had been presented as making up the two bodies which would have been at once equal in volume and equal in weight are further qualified as indivisible (τὰ δὲ πρῶτα καὶ ἄτομα).

¹ Professor W. J. Verdenius suggests to me a different interpretation of this moment in Aristotle's argument, whereby the concluding sentence of this first part of Aristotle's criticism, 308b35, ἴσα γὰρ ἂν ἦν τὸν ὄγκον, would mean: 'And this would make them equal in volume <only, and not guarantee an equal weight>'. For the ellipse of 'only' a number of passages are quoted by him in 'Critical and exegetical notes on *De caelo*', *Symposium Aristotelicum* 4 ed. I. Düring (Heidelberg, 1969) 271–2 (*ad i* 7, 276a6).

The disadvantage of this interpretation, it seems to me, is that if Plato's primary particles were able to produce two bodies the *same* in volume and *different* in weight then Plato would be half-way to explaining the discrepancy between size and weight which Aristotle here presents as precisely the point where Plato's theory fails, and as the jumping-off point, so to speak, for the Atomists' theory. I have therefore preferred to construe the subject at 308b35 as φαίνεται γὰρ . . ., 308b32).

Two groups of theorists are distinguished with elements of this kind.

1. There are those for whom the primary and indivisible elements are surfaces (τοῖς μὲν ἐπίπεδα λέγουσιν).
2. There are those for whom the primary and indivisible elements are solids (τοῖς δὲ στερεὰ ἢ τὰ πρῶτα καὶ ἄτομα λέγουσιν).

The distinction is the same as that which I noted earlier, in the preliminaries to the passage quoted in my second chapter, from the *De generatione et corruptione*. The first group are Platonists: the others are the Atomists.¹

(iii)

Of the Platonic view Aristotle writes: σωμάτων, ἄτοπον τὸ φάναι.

The 'absurdity' which Aristotle alludes to is entailed by the conjunction of ἐπίπεδα, and had been spelt out several pages earlier (iii 1, 299a25–300a19). Conceptually, therefore, the 'absurdity' of the Platonic view lies for Aristotle in the discontinuity between surface and solid, or more specifically in the discontinuity between surfaces and 'bodies which have weight'.

Formally, there are two possibilities.

1. It is perhaps possible that the discontinuity between surface and solid alone provides the object of τὸ φάναι.
2. But it is, I think, perhaps rather more natural to add to this notion as the object of δὲ τὸ ἐξ ἐλαττόνων.

¹ *De gen. et corr.* i 8, 325b24–36 (in part DK 67A7), p.41 above. The same distinction is repeated briefly after the passage concerning weight, 326a21–4 (not in DK).

In that case the point of the sentence will be:

'From equal primary elements which are surfaces it is ridiculous for the Platonists to produce bodies of equal weight, from more of them heavier bodies and from fewer of them lighter ones.'¹

(iv)

Adoption of this second element in the object of βαρύτερον ... τὸ ἐκ πλειόνων τῶν αὐτῶν συνεστός.

Put the other way round, the object of μᾶλλον ἐνδέχεται λέγειν, as we would expect them to be from the general parallelism between the two sentences.

1. 'It is ridiculous for the Platonists to produce . . . bodies where the larger is necessarily the heavier.'
2. 'The Atomists do instead have some right to say . . . that "the larger is the heavier".'

In itself, however, this degree of similarity between the object of λέγειν is not necessarily an indication that *what* is larger and *what* is heavier will be the same in the two cases.

For the two formulae, although similar, are not identical.

1. The Platonic formula necessarily refers to compound

¹ These two ways of taking the object of τὸ φάναι do not seem to have been considered explicitly hitherto. Stocks, in his Oxford translation, apparently takes the reference to be merely internal, as it were, and Longo, in his translation and edition, certainly does so, 263: 'Quanto alle parti prime e indivisibili, se si afferma che è di superfici che sono costituiti i corpi dotati di peso, si dice una assurdità'. Most translators, on the other hand, take the passage as I have done, including Moraux, Budé edn 139, and Guthrie, who translates neatly, Loeb edn 335: 'The statement'—about bodies of equal weight etc.—'is indeed ridiculous from those who postulate surfaces . . . '.

bodies: βαρύτερον ... τὸ ἐκ πλειόνων τῶν αὐτῶν συνεστός .

2. The atomic formula need not do so: τὸ μείζον εἶναι βαρύτερον αὐτῶν .

From the immediate context and use of language therefore the atomic formula may refer *either* to primary elements *or*, like the Platonic formula, to bodies formed from the elements.

To that choice we must return at the end of our preliminary analysis.¹

(v)

For the moment, the point which we need to appreciate is that Aristotle's invocation of the argument from his earlier analysis, on the question of the discontinuity between surface and solid, is not essential to his original critique.

The Platonists' inability to explain how the larger body can be lighter is what initially distinguishes them from the Atomists, and is also reckoned as the starting-off point for the Atomists' more sophisticated theory. The Platonists' radical inability to produce bodies which have weight at all, is a diversion from Aristotle's original argument.

Indeed so much so is this, that in the sentence immediately following his remarks about 'primary and indivisible elements' Aristotle has virtually to repeat the two points from the earlier part of his argument before he can continue his original train of thought.

1. He repeats the point that the larger body is not always the heavier.
2. He repeats the point that, on the contrary, the heavier body is often the smaller.

The *second* point is repeated directly.

1. Aristotle first wrote: φαίνεται γὰρ ἓνια τὸν ὄγκον μὲν ἐλάττω τῶν σωμάτων ὄντα, βαρύτερα δέ .
2. He now repeats this as: ἀλλὰ πολλὰ βαρύτερα ὁρώμεν ἐλάττω τὸν ὄγκον ὄντα .

¹ Pp.88–93 below.

The *first* point is repeated rather more deviously.

1. Aristotle first wrote: οὐχ ἱκανὸν τὸ φάσκειν ἐξ ἴσων συγκεῖσθαι τῶν πρώτων τὰ ἰσοβαρῆ· ἴσα γὰρ ἂν ἦν τὸν ὄγκον .

This latter formula, as I have noted, carries the sense of: (ἐξ ἴσων ... τῶν πρώτων ... and βαρύτερον μέν ... κουφότερον δέ ...) are the two sides, so to speak, of the same Platonic coin.

2. Aristotle now writes: οὐ φαίνεται τοῦτον ἔχειν ἕκαστον τὸν τρόπον .

The expression τὸ μείζον εἶναι βαρύτερον αὐτῶν , and therefore in effect resumes the sense of Aristotle's earlier formula.

So much is this a new start, that the Atomists have virtually to be introduced afresh.

1. Aristotle first wrote: τοῖς δ' οὐχ ἱκανὸν ἔδοξεν ... ἀλλὰ ... καινότερως ἐνόησαν περὶ τῶν νῦν λεχθέντων .
2. Aristotle now writes: ἕτερον τὸ αἷτιον οἴονται τε καὶ λέγουσιν ἔνιοι .

Aristotle's need to resume in this way the points of his earlier argument shows clearly that the intervening material, on 'primary and indivisible elements', is by way of an interlude in, or a digression from, his primary argument.

Thus the two sentences, τοῖς δὲ στερεά . . . , are not primarily designed to further the contrast between Platonists and Atomists in explaining discrepancy between size and weight in compound bodies. Rather, they form a subsidiary argument, which turns on the nature of the primary elements.

(vi)

After this interlude, Aristotle's argument is again plain sailing.

Aristotle resumes briefly the stages of his previous argument, as I have noted.

The difference between Platonists and Atomists is then pointed by a change in example.

1. The Platonists had been able to deal plausibly only with bodies that were at once larger and heavier, 308b7–8:
 ὥσπερ μολίβδου μόλιβδος ὁ πλείων βαρύτερος καὶ χαλκοῦ χαλκός .

2. The Atomists are able to cope with discrepancies between size and weight, καθάπερ ἐρίου χαλκόν .

The Atomists' trump card lies in the use of void (τὰ μείζω κουφότερα). For in such cases void explains the larger volume, without adding to the weight: the number of solid atoms may be the same or less.

Thus Aristotle arrives at the general conclusion (ὅλως δὲ καὶ παντὸς αἵτιον ... τοῦ κουφοτέρου) that in every case the presence of a larger quantity of void is the cause of one thing's being lighter than another.¹

The Double Argument

(i)

Thus in the passage as a whole there prove to be two disparate lines of argument.

1. The first argument turns on the question of how it is that the larger of two bodies may be the lighter. The answer, for the Atomists, lies in the presence of void in compound bodies.

The preliminary statement of this problem continues as

¹ Aristotle's recapitulation of the atomist theory has led some commentators—Rivaud and Elders—to suppose that the theory introduced after the digression on the primary elements (309a2ff.) is no longer the same as the theory which is contrasted to that of Plato at the beginning of the passage that I have quoted (308b28ff.). In so far as this notion rests simply on the failure to appreciate the sequence of thought and argument that I have already outlined it need not, I think, intrude further at this point. In Dr. Elders' case, the tendency to multiply

(footnote continued on next page)

far as τῶν δὲ συνθέτων (309a2); and the solution to the problem in terms of void occupies the remainder of the passage which I have quoted (309a2–11).

2. In between (308b35–309a2), there is a separate and secondary argument, which turns on the nature of the primary elements.

This division of interest is in itself enough to show that, simply from the point of view of context, τὸ μείζον εἶναι βαρύτερον αὐτῶν need not refer directly to compound bodies, for the pair of sentences in which that phrase occurs is not directly part of Aristotle's primary or initial argument, and need not therefore continue the interest in compound bodies on which that argument is centred.

(ii)

Thus preliminary analysis of Aristotle's argument shows that τὸ μείζον εἶναι βαρύτερον αὐτῶν need not refer to compound bodies. Further reflection shows that it cannot do so.

If αὐτῶν are compound bodies, then on the atomic theory they should be bodies made up from both solid and void. But sequence of language and sequence of thought alike make it impossible to introduce the distinction between atoms and bodies composed of atoms and void in this present context.

1. Bodies composed of atoms and void are introduced for the first time in an explicitly recognisable form at αὐτῶν to look forward to something which has not yet been mentioned.

(footnote continued from previous page)

the number of theories that Aristotle has to criticise springs from his misunderstanding of a number of passages, which I shall consider together in the earlier of my two essays on Aristotle.

There is an even more obvious error in Carteron, who writes, *La notion de force dans le système d'Aristote* (Paris, 1923) 40 n.141: 'C'était la supériorité de Démocrite sur Platon (2, 309a1–2) de pouvoir expliquer que le plus grand est le plus lourd'. Carteron has taken the concession—the point on which Plato and Democritus agree—as the principal point of the passage. The truth is just the opposite. It is in the case of compound bodies, where the larger is *not* always the heavier, that Democritus proves his superiority over Plato.

2. Even if αὐτῶν could somehow be taken to mean 'bodies composed of atoms and void', it would ruin the force of Aristotle's argument if such bodies were introduced at this juncture, outside the sequence of thought which leads to void as the explanation of the larger of two bodies being the lighter.

Thus if αὐτῶν are to be compound bodies at all, at this juncture they will have to be bodies made solely of atoms. The point would then be that from solid primary particles the Atomists could, with more justification than the Platonists, have produced compound bodies where the larger was the heavier.

But this would be a *nomen*, or rather a *sententia vacui*. It would be an account not of what the Atomists did *in fact* do, but of what they *could* have done, if they had made use only of atoms, and if they had advanced no further than the Platonic formula that 'the heavier is the larger'.

(iii)

It is far simpler, therefore, and more direct to suppose that the point of the sentence is not that the solids make up *other* bodies of which the larger can be the heavier: but that each solid is *itself* a body which has weight, and of which the larger is the heavier.

On this reading, the point of the argument will be that the Platonic primary elements, since they are surfaces, are useless for generating bodies with weight, of which in any case the larger would have to be heavier and the smaller lighter. The Atomists' primary bodies are at least solids: and to these there is some point in applying the Platonic formula that the larger is the heavier. It is when we turn to compounds (τῶν δὲ συνθέτων) that the formula 'larger and heavier' breaks down, and it is here that the Atomists introduce a new and different factor: the void.

Apart from making immediate sense of the passage, this interpretation has the crucial advantage that it gives proper force, and sense, to αὐτῶν immediately preceding.

I conclude therefore that from τῶν δὲ συνθέτων Aristotle reverts to his original argument, where the Atomists' inclusion of void in their compound bodies enables them to solve what Aristotle has presented as the Platonic dilemma of how the larger body can be the lighter. In the pair of preceding sentences, Aristotle is concerned to contrast not compound bodies, but primary elements.

1. The Platonic primary elements cannot properly produce bodies which have weight; nor therefore can they justify adequately even the limited theory of weight where the heavier body must always be the larger.
2. The Atomists start off from solid bodies having weight: and at this level they have some right to apply the formula that what is larger is heavier. The more difficult question, of how the larger body can be lighter, they solve by having compound bodies where atoms are joined with void.

The Two Equivalents

(i)

In an earlier argument, I commented on the ambiguity in the relation of the atoms to Aristotle's elements. The atoms can be thought of as corresponding to Aristotle's own elements, including fire and earth, or they can be thought of as elemental particles prior to the formation of earth and fire.¹

The present point is perhaps clearer, if again we reflect that there are two possible equivalents in the atomic system to the Platonic distinction between surfaces and 'bodies which have weight'.

From *one* point of view, the 'bodies which have weight', in the Platonic system, are bodies made up from the elements (surfaces or triangles); and so will correspond to bodies compounded of atoms and the void. On this reckoning:

1. Platonic solids correspond to bodies composed of atoms and the void.

¹ Pp.37–8 above.

2. Platonic surfaces therefore correspond to atoms.

However, from *another* point of view, surfaces and solids are contrasted, and therefore atoms are equivalent not to surfaces, but to the three dimensional bodies which, on the Platonic system, are generated from surfaces.

From this point of view:

- 1. Platonic solids, composed of surfaces, correspond to the atoms.
- 2. Platonic surfaces have no direct equivalent in the atomic system.

Thus there is a certain ambiguity in the relation of atoms to the Platonic system.

- 1. From one point of view, atoms *correspond to* surfaces and are therefore *distinct from* the three dimensional bodies which on the Platonic system are generated from surfaces.
- 2. From the other point of view, atoms are *distinct from* surfaces and *correspond to* the three dimensional bodies which are formed from surfaces.

The point can perhaps best be appreciated diagrammatically.

Plato	Atomic equivalence (1)	Atomic equivalence (2)
surfaces	atoms (as the primary elements)	_____
solids	bodies compounded of atoms and void	atoms (as solid particles)
_____	_____	bodies compounded of atoms and void

(ii)

In his main argument, Aristotle is concerned with the *first* equivalence, since it is at this level that the Atomists are able to explain, by their introduction and use of the void, how the larger compound body is the lighter, while the Platonists are condemned to having the larger compound body always the heavier.

The *second* equivalence would be useless for this purpose, for if atoms correspond to Platonic solids then bodies compounded of atoms and the void have no direct equivalent in the Platonic system, and the point of the contrast, between Platonic solid bodies, where the larger is always necessarily the heavier, and the atomic compound bodies, where the larger body can be lighter is therefore lost.

On the other hand, in his parenthesis on the primary elements, Aristotle starts precisely from the *contrast* of surface and solid, and it is likely therefore that he will intend the *second* equivalence when in this context he writes that 'the larger is the heavier'.

For the point is that the Atomists are able to *escape from* the necessary conjunction of weight and volume in their account of the compound bodies, while they *retain* that conjunction on the level of the primary elements.

On the level of the primary elements, the Atomists' advantage over Plato lies not in their ability to account for discrepancies of size and of volume, but in their choice of solid bodies as distinct from surfaces.

To resume: Platonic solids, composed of surfaces, can be seen as equivalent *either* (1) to bodies compounded of atoms and the void *or* (2) to the atoms alone. In the *first* case, the Atomists escape from the necessary conjunction of weight and size by their use of void, which allows the larger body to be lighter. In the *second* case, the Atomists, like Plato, are restricted to the rule that the larger body is the heavier, and the difference lies only in the point that for the Atomists the primary elements are solids and not surfaces.

Other Interpreters

Guthrie and Cherniss

(i)

Neither Cherniss nor Professor Guthrie appears to show any recognition of the two strands in Aristotle's argumentation, nor therefore any awareness that the two sentences which in one guise or another contain the formula that the larger is the heavier are not directly part of Aristotle's primary sequence of thought. Consequently, they recognise only the *first* equivalence, and attempt to apply this to the whole passage, and so to force a distinction between αὐτῶν.

This leads them to assume that the similarity which I noted in the course of my preliminary analysis between the Platonic formula (τὸ μείζον εἶναι βαρύτερον αὐτῶν) entails an identity of object, and must therefore indicate, for Plato and for the Atomists alike, compound bodies, as distinct from Platonic surfaces or atomic solids.

(ii)

This, at least, is how I interpret Cherniss' processes of thought. For if we look back to discover how Cherniss has 'shown conclusively' (as Professor Guthrie tells us) that atoms are not intended by αὐτῶν, we find in fact little more than brief paraphrase and bare assertion.

The only sentences offered by Cherniss which are demonstrative in form run as follows:

'Those who make the elements corporeal can with greater reason say that the larger compound body is the heavier. This neither says nor implies that the larger atom is heavier than the smaller, for the explanation would have to hold also for different volumes of the same kind, i.e. consisting of a different number of atoms of the same size.'¹

¹ *ACP* 211 n.253, cf. pp.81–2 above.

I am not entirely clear what precise argumentative force Cherniss' observations are intended to display at this point. Cherniss seems to assume as his premiss that compound bodies are intended by αὐτῶν, and to conclude from this that compound bodies which are heavier and larger need not require the atoms which form them to be heavier and larger as well, since one compound body could be heavier and larger than another because it was constituted of a greater number of atoms of the same size as the atoms which constitute the smaller compound body.

This conclusion is true, but the truth of the conclusion does not prove the truth of the premiss: no reason is given for supposing that compound bodies, and not atoms, are in fact the subject of Aristotle's formula.

Essentially, Cherniss and Guthrie fail to show any recognition of the hiatus in Aristotle's main line of thought, caused by the contrast of Platonic surfaces and atomic solids, nor any appreciation of there being two possible sets of equivalents which will embrace the Atomists' primary elements and those of Plato.

Simplicius

As it is, Cherniss' most powerful argument lies not in any detailed analysis of Aristotle's reasoning, but in his claim that Simplicius' interpretation of the passage agrees with his own.¹

But this claim proves to be ill-founded.

(i)

Simplicius, it is true, in his elaboration of Aristotle's critique, does make atoms the cause of compound bodies' being heavier and larger, *De caelo* 685.13–17: τὰς ἀτόμους αἰτιᾶσθαι δύνανται δι' ἐκείνας γὰρ τὸ μείζον βαρύτερον ἀνάγκη εἶναι.

¹Since the facts of experience do not accord (οὐ φαίνεται) with the belief that each of the compound bodies obeys this rule, namely that the larger <body> is invariably the

¹ACP 211 n.253.

heavier . . . it follows that atoms <alone> cannot be held responsible <for the differences that we observe in the weight of bodies>, for atoms <alone> do of necessity make the larger <body> heavier.¹

Simplicius writes thus, because he adopts the formula that atoms are cause of heaviness and that void is cause of lightness, so that atoms cause the larger body to be heavier, while void causes the larger body to be lighter.¹

(ii)

But this does not make Simplicius' interpretation the same as that of Cherniss, for Simplicius starts out precisely by acknowledging a difference of weight in the atoms, and by paraphrasing in this sense Aristotle's formula, that 'the larger of them is the heavier'. He writes, *De caelo* 685.9–11:

γὰρ ὄντα καὶ αὐτὰ τὰ ἐξ ὧν ἔστιν ἄλλ'. οὐκ ἐπίπεδα ῥοπήν ἔχει καὶ αὐτὰ τινα .

I translate:

'Those who state that the primary elements are solids, as do Democritus and his associates, are entitled to claim that the larger is the heavier. For the things from which bodies are compounded (ῥοπήν ἔχει ... τινα) .

(iii)

Correctly interpreted, therefore, Simplicius' commentary serves only to reinforce the interpretation that I have given.

In the earlier passage (685.9–11), Simplicius employs Aristotle's formula, whereby the larger is the heavier, as a description of the atoms or 'solids'. Simplicius explains that the larger atom or 'solid' can be the heavier because the atoms which make up

¹ *De caelo* 684.19–22, cf. 685.22–4. The place of this interpretation in Aristotle's analysis of the atomic theory as a whole will be taken account of in my third essay.

bodies are themselves bodies which have weight, unlike the weightless surfaces of Plato's theory.

In the following passage (685.13–17), Simplicius' point is that even atoms which have weight cannot explain the discrepancy between size and volume, whereby the larger compound body is *not* always the heavier. At this point therefore Simplicius does employ Aristotle's formula to describe compound bodies; but he does so only in order to point up the limitation of the atomic theory, on the level of the primary solids, and the need therefore for an additional factor, void, in order to explain the discrepancy between size and volume among the compound bodies (*cf.* 685.17 ff.).

In the passage as a whole, therefore, Simplicius' point, as Aristotle's point, is that by the introduction of void the Atomists *escape* from the rule to which they are bound in their analysis of the weight of individual atoms. For the Atomists, the rule whereby the larger is the heavier applies only to the individual atoms or 'solids', and not to bodies compounded of atoms and void.¹

'It is Possible to Say . . .'

There remains a final difficulty. Aristotle writes: *μᾶλλον ἐνδέχεται λέγειν . . .* It may be objected that this means that the Atomists *could* have said, not that they *did* say.

The degree of objectivity in Aristotle's account of the atomic theory, particularly in the light of his use of the theory as part of his criticism of Plato, will be given some attention in the following two sections of this chapter. For the moment I consider only the more immediate implication of *ἐνδέχεται*.

The ambiguity that I have noted cannot perhaps be resolved conclusively. Nonetheless it seems to me that if Aristotle had intended to contrast an actual belief of the Platonists with a hypo-

¹ It is interesting to note that when, in the later passage (685.13–17), Simplicius writes that atoms alone are inadequate as an account of the weight of compound bodies, he comes close to the idea which I noted earlier (pp.89–90) of a body 'compounded' of atoms alone. Simplicius' commentary makes clear that this is an entirely hypothetical construct, designed solely to highlight the *impasse* which the Atomists avoided by the introduction of void. It is only in the context of this hypothetical—and ultimately impossible—theory that the larger compound body would be, for the Atomists, invariably the heavier.

thetical consequence of the atomic theory he would more naturally have written $\mu\alpha\lambda\lambda\omicron\nu \alpha\nu \epsilon\nu\delta\acute{\epsilon}\chi\omicron\iota\tau\omicron$ or $\epsilon\nu\epsilon\delta\acute{\epsilon}\chi\epsilon\tau\omicron$. As it is, the plain use of the indicative, in the present tense, will I think most naturally mean only that the Atomists 'do have some right to say, as they do . . . '.

If the sentence is taken in this sense, then the qualification contained in ($\mu\alpha\lambda\lambda\omicron\nu \epsilon\nu\delta\acute{\epsilon}\chi\epsilon\tau\alpha\iota$).¹

Conclusion

I paraphrase therefore:²

Contrast between the Atomists and Plato

'There were those then who explained and defined heavy and light in the way I have described.

'Others did not consider that the distinction and definition of heavy and light on these lines was adequate, and although they belonged to an earlier generation their ideas on the subject of our present enquiry were novel and more up-to-date.

'The obvious fact is that some bodies are smaller in bulk than others, while being heavier than them.

'From this it plainly follows that it is not good enough to

¹ From this point of view it is important to note that the meaning of $\mu\alpha\lambda\lambda\omicron\nu$.

In these paragraphs I anticipate the conclusion of my study of Aristotle's criticism of Plato's theory, taken account of in my second essay, where I argue that Aristotle's exposition does represent, from his own point of view, the essential features of Plato's belief.

² *De caelo* iv 2, 308b28–309a11, quoted pp.80–1 above.

claim that bodies of equal weight are composed of equal primary elements. For this would make bodies <that are equal in weight> equal in volume, <and an increase or diminution of weight could then be achieved only by an increase or diminution of volume>.

Parenthesis on the Primary Elements

'In both systems, the primary elements are indivisible.

'The one group maintains that they are surfaces; and that from these surfaces are built up bodies that have weight. <On this basis,> their claim <to explain weight even in the way that has been described> is absurd.

'The other group accounts the primary elements as solids. They do <therefore> instead have some right to claim <as they do> that the larger of these is the heavier.

Continuation of the Contrast between the Atomists and Plato

'With compound bodies it is different.

'It is obvious that each of the compound bodies does not follow the rule <that the larger is the heavier>.

'On the contrary, we see that many compound bodies are heavier, and yet smaller in bulk. <A small piece of> bronze, for example, <is heavier> than <a pile of> wool.

'To account for this, some people reckon that for compound bodies there must be a different cause of weight, and they express themselves accordingly. They claim that it is void that gives bodies buoyancy by getting trapped and shut up inside them.

'This it is, they claim, that brings it about that there are times when larger bodies are lighter. The reason is that they have more void: that is why some bodies are larger in volume than something else, although they are often made up of an equal number, or even fewer, solid pieces than the other thing.

The Atomists' Definition of how One Thing is Lighter than Another

'As a general rule, then, and in every case they claim that

the cause of one thing's being lighter <than another> is the fact that there is more void present inside it.'

§ 2—

Compound Bodies

(i)

In the *De generatione et corruptione* we are told that Democritus' atoms differ in weight according to their 'preponderance'. From the *De caelo* we learn, I believe, that this difference in weight of the atoms is in fact correlated with a difference of size, so that the larger an atom is the heavier it will be.

From this vantage point, therefore, it is possible to look back at the expression *ὑπεροχή* does not in itself *mean* a larger size, it is now possible, in the light of my analysis of the passage from the *De caelo*, to see that the *implication* of the expression from the *De generatione et corruptione* will be virtually the same as the meaning of the expression from the *De caelo*.

1. In the *De caelo*: 'the larger of them <the atoms> is heavier' (iv 2, 309a2).

2. In the *De generatione et corruptione*: 'each of the indivisibles is heavier according to its preponderance <of size>' (i 8, 326a9).¹

¹ For the dispute over the meaning of *ὑπεροχή* see pp.43–8 and 61–2 above. From this same point of view, we may accept the suggestion of Verdenius and Waszink, *Comments* 42, that the sentence in the *De generatione et corruptione* 'may be explained as a contamination of two ideas, "each atom has weight" and "an atom is the heavier the larger it is".' I prefer however not to base the initial interpretation of the passage in the *De generatione et corruptione* directly on the notion of size, and therefore I would retain as the primary implication of the passage my conclusion whereby the 'other half' of the comparison is that each atom will be 'more heavy <or less so>' according to its 'preponderance <or deficiency>', cf. pp.61–2 above.

For the place of the *De generatione et corruptione* in a summary of the evidence from both Aristotle and Theophrastus, see below p.150.

(ii)

But there is now a fresh problem. In the *De caelo* Aristotle adds a definition of lightness: '... in every case the cause of one thing's being lighter <than another> is the fact that there is more void present inside it' (*cf.* iv 2, 309a10–11).

What precisely is the meaning of this formula?

1. Does the formula which Aristotle has presented mean simply that we compare the amount of void in one body with the amount of void in a second body?
2. Or does it require us to compare the proportion of void to solid in one body with the proportion of void to solid in a second body?

There is a real distinction between these two formulae, for a body which has more void than another, absolutely speaking, may nonetheless have a smaller proportion of void to solid than the second body has.

Nonetheless I shall suggest either that the Atomists themselves failed to choose between the two formulae, or that for them this was in practice a distinction without a difference.

This, I believe, is the inference that can be drawn from the continuation of Aristotle's analysis.¹

The Corollary

In the passage which immediately follows the comparison between Democritus and Plato quoted at length in the first section

¹ Here, as in my paraphrase (p.100 above), I have taken the expression 'what is lighter' (iv 2, 309a10–11) to imply a comparison between two different bodies. It would be possible to imagine taking a single body, and increasing the amount of void inside it, so as to make the one body 'lighter' than it was before. But this would mean that the proportion of void to solid in the body in its later state was greater than the proportion of void to solid in the body in its earlier state, and so would coincide in its result with the comparison, between different bodies, of the proportion of void to solid in each.

My paraphrase also excludes the possibility that a body is said to be lighter if it has more void than solid. When Aristotle repeats the Atomists' formula he makes it explicit that the one body has more void 'than other bodies do' (*cf.* 309a29–30).

of this chapter, Aristotle adds a significant corollary to the atomic theory.

It is not enough, he tells us, to specify that one body will be lighter than another in virtue of having more void. The amount of solid that it has must also be less. For if the body which has more void were to 'overstep the analogy' then it would no longer be lighter.

Aristotle writes, *De caelo* iv 2, 309a11–18: εἰ μὴ καὶ στερεὸν ἔξει πολλαπλάσιον ὥστε τοῦτο λεκτέον.

The precise nature of Aristotle's 'analogy' has caused much bewilderment. The question is a complex one, and I shall leave a full discussion therefore until the first of my later two essays on Aristotle.

The conclusion I shall argue to there is that Aristotle writes explicitly of the comparison of void to void and of solid to solid between one body and another, while at the same time his analysis requires a comparison, between the two bodies, of the proportion of void to solid in each.

1. Thus the body which will exemplify the analogy is a body which is larger and lighter than another. This is the body which Aristotle presents as the Atomists' answer to Plato.
2. The danger, the 'overstepping' of the analogy, lies in the appearance of a body which will be larger and heavier. This is the kind of body that the Platonists can produce, even without the help of void.

The *first* body Aristotle supposes will have more void and less solid than another, while from this it follows that it will also have a greater proportion of void to solid than the body to which it is compared.

The *second* body Aristotle supposes has more void and more solid than another, while at the same time he takes for granted at

this point, or possibly overlooks, the necessity for it also to have a greater proportion of solid to void than the body to which it is compared.

I paraphrase therefore:

'That then is how they express their theory.

'But when the definition of lightness is cast in this form, we must add, not only that the body in question, if it is to be lighter, has more void, but also that the solid it has is less.

'For if the body in question oversteps this ratio <so that instead of there being more void and *less* solid there is more void and *more* solid>, then <while it will still be larger> it will no longer <necessarily> be lighter.

'Take the example of fire, which they say is lightest of all because it has most void.

'If that is all they say,> then a lot of gold will turn out to have more void than a little fire, and so will be lighter, unless it is going to have many times the quantity of solid as well.

'So this <—the comparison of solid—> needs to be specified <as well as the comparison of void>.¹

Differences of Volume

What is significant for my immediate purpose is that Aristotle's corollary, on the need to specify the comparison of solid, is true only when the bodies being compared have a different volume.

(i)

Thus if one body has more void, or has less void, than another, and has a *different* volume, then from that fact alone we cannot tell whether it will have more solid than the second body, or less.

This it is that provokes the need for Aristotle's corollary. In his final definition Aristotle tells us that the Atomists have defined as

¹ There is a slight anacolouthon in Aristotle's expression, which I have carried over into the second paragraph of my paraphrase. The original definition is that there should be more void, and what we 'add' to it therefore is only that there should be less solid. The notion of μή μόνον ... ἀλλὰ καί.

lighter a body which has more void than another (309a10–11).

1. A body which has more void than another may also have less solid, and in that case, according to the interpretation that I have outlined, Aristotle supposes that it will be larger and *lighter*.
2. But a body which has more void than another may also have more solid as well, and in that case, according to the interpretation that I have outlined, Aristotle supposes that it will be larger and *heavier*.

The point to note is that in the *second* case the infringement of the Atomists' formula, the 'overstepping' of the analogy, is possible only if the two bodies differ in volume. A body can have more void *and* more solid, *only* if it is also the larger of the two.

(ii)

If two bodies both have the *same* volume, then an increase or diminution of void can be attained only by a corresponding diminution or increase of solid matter.

There will be no need therefore to add explicitly that there must be less solid, or that there must be more.

1. If the two bodies are the same size, then the one which has more void than the other will necessarily have less solid.
2. Similarly, if the two bodies are the same size, then the one with less void than the other will necessarily have more solid.

In the *first* case, therefore, it will be sufficient to say simply that the body with more void in it is the lighter, since for there to be more void there must be either fewer or smaller atoms.

In the *second* case, it will be sufficient to say simply that the body with less void will be the heavier, since for there to be less void there must be either more or larger atoms.

(iii)

Aristotle's corollary, on the need to specify the comparison of

solid matter, will most probably, it seems to me, imply that the Atomists themselves in fact defined one body as lighter than another solely with reference to the amount of void it contained.

There are therefore two possibilities.

The one possibility is that the Atomists themselves neglected to consider the comparison of volume in their definition of how one body is lighter than another.

The alternative possibility is that the Atomists' own formulations about the weight of compound bodies were cast explicitly, or by implication, in terms of bodies of equal volumes, since these are the one instance where a body can be defined as lighter or as heavier than another solely in terms of the amount of void which it contains, with no need to add any corollary about the amount of solid matter also being more or less: if the two bodies compared are equal in volume, then the comparison of void with void will entail the comparison of solid with solid and no less the comparison, between the two bodies, of the proportion of void to solid in each.¹

Conclusion

I conclude that most probably the Atomists' definition of how one body is lighter than another will have been sufficiently expressed by the formula that a lighter body will be the one that has more void, *either* because the comparison of volumes was left out of account, *or* because the volumes of the two bodies being compared were thought of as equal, so that the body with more void than another would also necessarily be the body which had less solid. In this second case, the comparison between two bodies of void with void would necessarily have carried with it the comparison of solid with solid, and the comparison between the two bodies of the proportion of solid to void in each.

¹ It may be noted that the comparison of void with void, even between two bodies that are equal in volume, does not entail any information about the proportion of void to solid within the one body, i.e. we cannot tell whether within one body there will be more void than solid or *vice versa*. This and other intricacies are pursued in my third essay, which contains a much more detailed analysis of Aristotle's criticism of the atomic theory at this point.

§ 3—

Aristotle's Criticism

I have concluded that the Atomists themselves, in their definition of lightness, either left the comparison of volumes out of account, or intended their definition to apply to bodies that were equal in volume.

This conclusion is confirmed, I suggest, if we look at Aristotle's 'corollary' to the atomic theory (iv 2, 309a11–18) in the light of two other passages, first the penultimate definition of lightness in Aristotle's comparison of the Atomists and Plato, and secondly the comparison of earth and fire in Aristotle's criticism of the atomic theory.

The Penultimate Definition**(i)**

The final definition of the atomic theory of lightness, preceding the 'corollary', states that 'as a general rule and in every case the cause of one thing's being lighter <than another> is the fact that there is more void present inside it' (iv 2, 309a10–11). This is the definition which Aristotle claims is incomplete, and to which the Atomists need to 'add' the specification of solid (309a11–18).

The penultimate definition which Aristotle provides for the atomic theory of lightness, in the passage which I analysed earlier, is as follows, *De caelo* iv 2, 309a6–10: ἐξ ἴσων στερεῶν ἢ καὶ ἐλαττόνων.

I paraphrase again:

'It is the void which gets trapped inside bodies that makes them lighter, or so they claim, and that brings it about that there are times when the larger bodies are the lighter ones, the reason being that they have more void inside them; this is how it comes about that they are larger in bulk than the others, despite the fact that often they are made up of an equal number, or even fewer, solid pieces.'

This definition *does* specify the amount of solid: συγκείμενα πολλακίς ἐξ ἴσων στερεῶν ἢ καὶ ἐλαττόνων .

Therefore, even when Aristotle would seem to be giving the Atomists' own explanation of lightness, in fact, on his own admission, he *cannot* be doing so. For the penultimate definition, since it specifies the comparison both of void *and* of solid, cannot be open to the correction that 'those who define what is lighter thus' (τοῖς οὕτω διορίζουσι , 309a12ff.) must add the comparison of solid to a definition expressed solely in terms of void.

I conclude therefore:

1. The penultimate definition (iv 2, 309a6–10) is inaccurate, historically, at once in the deliberate application of the formula to bodies which differ in size, and also in the specification which it therefore has to provide of the comparison of solid matter.
2. The final definition (ὅλως δέ , 309a10–11) will be historically accurate in expressing the definition of lightness solely in terms of the quantity or proportion of void, as a result *either* of the Atomists' failing to consider the comparative size of the bodies in question, *or* of their taking for granted that the two bodies being compared are equal in volume.

(ii)

By far the most likely reason for this, it seems to me, lies in the context of Aristotle's criticism of Plato. Aristotle has himself cast the atomic theory into a form which will put Plato at a disadvantage.

In so doing, Aristotle has been drawn into an elaboration of the atomic theory in terms of bodies which differ in volume, and he has therefore been led to specify the comparison of solid matter. For only in this way can the atomic theory be made to work as a refutation of Plato.

From this it seems to me clear that only the generalising conclusion to the atomic definition of weight, namely that the lighter body is the one with the more void, can be historically accurate, 309a10–11: εἶναι τοῦ κουφοτέρου τὸ πλεῖον ἐνυπάρχειν κενόν .

The preceding definition, on Aristotle's own showing, is inaccurate in the specification which it provides of the comparison of solid matter.

'Gold and Fire' and 'Earth and Fire'

By a fortunate chance, the discrepancy between weight and volume is relevant not only to Aristotle's initial presentation of the atomic theory in the context of his comparison with Plato, but no less to his criticism of the theory in the following pages of the *De caelo*.

The form which this later criticism takes provides us, I suggest, with renewed reason for supposing that the Atomists' own formulation of their theory was not cast in the form of a comparison between bodies which differed in volume.

(i)

After his contrast of Plato and the Atomists, Aristotle's attitude changes completely. Instead of saying that the Atomists, unlike Plato, were able to cope with discrepancies between weight and volume, Aristotle now claims that the Atomists are 'caught in the same difficulties' as are those, like Plato, who exclude the void.

The turns and twists of Aristotle's argument at this point are more than usually complex. Again therefore I reserve a detailed analysis for my commentary on book four of the *De caelo* as a whole, and proceed here from the conclusions which I shall argue to later.¹

The argument which Aristotle eventually arrives at runs as follows, iv 2, 309a33–b4: αἰ ἄνω αὐτὸ φερόμενον αἰ κάτω. τοῦτο δὲ ἀδύνατον .

¹ Meanwhile cf. pp.16–19 above.

I paraphrase:

'... how will they define what is heavy absolutely?

'*Either* it will be by its having more solid, *or* it will be by its having less void.

'If that is the definition they offer, then <on the *first* alternative> there will be a certain quantity of earth so tiny that in it there will be less solid than in a huge quantity of fire.

'<In that case, fire will end up being heavier than earth.>

'There will be an equivalent circumstance if <pursuing the *second* alternative> they phrase the definition in terms of void: <i.e. there will be a certain quantity of earth so large that in it there will be more void than in a tiny quantity of fire.>

'In that case there will end up being something lighter than what is light absolutely.

'Indeed, what is always <and only> borne downwards <namely earth> will be the very thing (αὐτό) that is lighter than what always <and only> moves upwards <namely fire>.

'That is impossible.'

(ii)

What is interesting about the second member in Aristotle's argument, once we have, as it were, unfolded it from its cocoon, is that the comparison it envisages corresponds exactly to the comparison of gold and fire which Aristotle added as part of the corollary to his earlier critique of the Atomists.¹

1. In his earlier passage, Aristotle compared a large quantity of *gold* with a tiny quantity of fire.
2. In his present argument, Aristotle compares a large quantity of *earth* with a tiny quantity of fire.

But the results in the two passages are exactly the opposite.

1. In his earlier argument, Aristotle said that it was not

¹ The earlier passage is iv 2, 309a11–18, paraphrased p.103 above.

enough for something larger and lighter to have more void: it must also have less solid. For a large quantity of gold could have more void than a tiny quantity of fire, and so would be lighter, except that it has many times more solid, and so is in fact *heavier* than fire.

2. In the present argument, a large quantity of earth has more void than a tiny quantity of fire, so that earth is *lighter* than fire.

The immediate reason for this reversal is that the defence, εἰ μὴ καὶ στερεὸν ἔξει πολλαπλάσιον, which Aristotle provided in the earlier passage, when he was taking the side of the Atomists, as it were, against Plato, is precluded in the later passage by the polemical decision to treat *either* void *or* solid as cause of weight.

Because of this, it comes about that Aristotle treats a body with more void and with more solid than another, in his *earlier* argument as being the *heavier* of the two (in virtue of its having more solid), and in his *later* argument as being the *lighter* of the two (in virtue of its having more void).

This duplication and contradiction strongly suggests that the Atomists themselves did not adapt their theory to a circumstance where one body could have both more void and more solid than another.

This in turn confirms my earlier conclusion that the Atomists themselves either failed to consider the comparison of volumes or alternatively limited themselves to bodies of equal size, where the one can have more solid only if it has proportionately less void than the other (and so is the heavier of the two), or less solid only if it has proportionately more void (and so is the lighter of the two).

Aristotle is able to treat the same circumstance, a lot of gold or earth and a little fire, as producing a body indiscriminately lighter or heavier than another, only, I suspect, because in dealing with bodies of different volumes he is able to exploit a circumstance not catered for by the Atomists' own expression of their theory.¹

¹ The criticism which Aristotle makes may seem to us trivial. By comparing bodies that are equal in volume we establish specific weight: then to complain, as Aristotle does in the first branch of the argument I have paraphrased (iv 2, 309a34–b2), that a larger quantity of the lighter body is nonetheless 'heavier' has

(footnote continued on next page)

Conclusion

(i)

The more particular conclusion I would draw from these passages is that most likely the Atomists themselves had not cast their theory in terms of a comparison between bodies that were different in size, and that Aristotle's presentation of the Atomists' theory specifically in terms of bodies of different volumes is probably the result solely of the exigencies of his comparison with Plato.

Because he has decided to present Plato's theory at this point as failing because of its inability to explain discrepancies between size and weight, and because he chooses to present the atomic theory as an advance upon Plato, Aristotle is led to portray the atomic theory as designed primarily to explain how one body that is larger than another can nonetheless be lighter.

This leads to the anomaly that although the penultimate definition of the atomic theory *does* specify the quantity of solid (309a8–10), nonetheless the final definition specifies only the comparison of void (309a10–11), with the result that in what I have called his

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as much, and as little, point, we may think, as to compare a pound of feathers and an ounce of lead.

Possibly some appreciation of the distinction between gross weight and specific weight explains why the Atomists were able to take the comparison of equal volumes for granted, if that is what they did. But in my fourth essay I shall seek to show that that distinction has no proper place in Aristotle's own theory, and that Aristotle is therefore able in part to ignore what we see as the distinction between gross weight and specific weight in his refutation both of Plato's theory and of the atomic theory.

Other points in Aristotle's critique of the Atomists in book four of the *De caelo*, and notably his specification of the quantity of atoms by number and not by size (e.g. he speaks of 'an equal number, or fewer, solid parts', iv 2, 309a9–10), I must also leave for my second and third essays: I would note only that the point I have mentioned also springs, I believe, from Aristotle's association of the Atomists with Plato.

In particular, I have left aside, for the present, consideration of the primary thrust of Aristotle's critique, whereby although Aristotle establishes the Atomists' superiority to Plato in terms of the discrepancy between weight and size in compound bodies (e.g. the comparison of wool and bronze at iv 2, 309a2ff.) nonetheless his final intention is to establish not merely that some compound bodies are lighter and larger than others, but that in his own theory an element (not a compound body) which is light by nature, and more especially fire, which is light absolutely, is invariably lighter in the larger quantity.

'corollary' Aristotle is led to complain that the Atomists have *failed* to specify the comparison of solid (309a11–18).

There is then the further anomaly that although Aristotle's corollary is designed to *reinforce* the Atomists' theory, by specifying the comparison of solid (309a11–18), nonetheless the same comparison is later used to *controvert* the atomic theory (309a33–b4), by showing that extreme discrepancies of volume undermine a definition of weight in terms of solid or void by producing circumstances contrary to (Aristotle's own theory of) the elements' behaviour as characterised by absolute weight.

My suggestion is that both anomalies have arisen because in deliberately dealing with bodies that differ in volume, in order to further his critique of Plato, Aristotle is exploiting a circumstance not directly catered for by the Atomists' own formulation of their theory.¹

(ii)

Very briefly, therefore, I turn to look more generally at Aristotle's evidence on both points: the individual atoms and bodies compounded of atoms and void.

It is symptomatic of Cherniss' attitude towards Aristotle that, having argued that in the passage from the *De caelo* Aristotle does not attribute weight to the atoms, Cherniss nonetheless adds that even if he had done so it would have been as the result of a misunderstanding. For once, Aristotle has not misunderstood a piece of Presocratic theory, if only because he has said nothing about it; but we are assured all the same that if he had said something on the subject he would still have been wrong!

Cherniss' argument, if we leave aside the doxographical material which I shall consider separately later, is that Aristotle 'would

¹ Inevitably, this point has been missed or denied. Moraux takes the Atomists' theory to have been expressly intended by its authors as an explanation of the discrepancy between weight and volume, Budé edn cxliii: 'Les Abdéritains . . . n'ont pas seulement voulu expliquer les différences de poids entre les corps, mais ont surtout noté le fait que certains corps, moins volumineux que d'autres, peuvent être plus pesants qu'eux. C'est par la présence d'un vide plus ou moins abondant à l'intérieur des corps qu'ils ont cru pouvoir expliquer cette anomalie'. I think that this reading of Aristotle's text has arisen only because the points I have adduced in the preceding pages have not been sufficiently attended to.

have maintained the necessity of attributing weight to the atoms if the complex bodies were to have weight'.¹

The precise intention of Cherniss' observation is again not wholly clear to me, but the point is evidently that the contrast between Plato and the Atomists on surfaces and solids would have led Aristotle to attribute weight to the atoms, even if Democritus had not himself done so.²

Quod gratis asseritur, gratis negatur. If I have interpreted Cherniss' argument aright, then we can as well argue that Aristotle would not have presented his contrast between the Atomists and Plato in this form, or at all, if Democritus had not in fact described his atoms as having weight.³

But the point I would make is not only a negative one. I do of course agree that, here as elsewhere, Aristotle's presentation of earlier theories has been coloured by his own ideas. But the colouring is more subtle than Cherniss appreciates. In particular, precisely because we can isolate, with reasonable certainty, the nature and so the probable extent of Aristotle's manipulation of—in this case—the atomic theory, so therefore we can, with more confidence, it seems to me, claim to discern in Aristotle's presentation of the theory what it is that does not take its colour from Aristotle's criticism.

Thus differences of volume persistently determine Aristotle's presentation of the atomic theory in the *De caelo*; nonetheless this will not, I think, vitiate the bones of the theory which we are able

¹ ACP 211 n.253.

² ACP 211 n.253. On the difficulty of locating Cherniss' argument see p.17 n.1 above.

³ The argument that Aristotle attributes weight to the atoms only because the complex bodies have weight, appears in fact to be an unacknowledged (and perhaps unconscious) adaptation of part of Simplicius' commentary on this passage of the *De caelo*: 'the things from which bodies are compounded are themselves bodies . . . and so do themselves also have a certain weight' (685.10–11; cf. pp.95–7 above). But even in Simplicius this argument is presented solely by way of clarifying the Atomists' position, and is in no way introduced as representing or implying that the Atomists themselves denied weight to the atoms. Elsewhere, as we shall see (ch. V p.153ff.), Simplicius writes explicitly that the weight of atoms was part of the original, pre-Platonic version of the atomic theory; and in an earlier passage of his commentary he puts the argument exploited by Cherniss the other way round, *De caelo* 269.12–14 (pp.161–3 below): ' . . . as the atoms, they claimed, were full <or dense>, they were heavy themselves and causes of heaviness in compound bodies'.

to discern in the *De caelo* and in the *De generatione et corruptione*. It will remain true that atoms differ in weight and in size, so that the larger an atom is the heavier it will be; while for compound bodies, at least for compound bodies of the same size, or for compound bodies where the difference of volume is not specified, lightness will be in proportion to the amount of void they contain.¹

¹ Despite the general nature of these remarks I am deliberately leaving aside, for consideration in a later chapter, a more general evaluation of the accuracy of Aristotle's evidence, and in particular I am leaving aside at this stage the question of the influence of Aristotle's own ideas on the way in which he thinks of the movement of the atoms: see ch.IX § 3, pp.260–6 below, esp. pp.261–2.

Chapter Four— Theophrastus

§ 1— Statement of the Theory

Orientation

I turn to the only other author in antiquity, apart from Aristotle, who will have known of Democritus' theory of weight at first hand, and who writes on it specifically: this is Aristotle's pupil, Theophrastus.

In the long extract on the nature of the senses and of the objects of sense, which is the only continuous portion that survives in an unabridged form from Theophrastus' writings on the history of philosophy, there are contained summaries and criticisms both of Democritus' theory of weight and of that of Plato, as well as some invaluable remarks on the nature of weight in earlier theories more generally.

Each of these three sections of Theophrastus' treatise is therefore of primary importance for my present study.

1. Theophrastus' long criticisms of Plato's theory have, I believe, been radically misunderstood by earlier scholars: a misunderstanding which has certainly added to, if it has not been a primary cause of, what I believe is the general misinterpretation of Plato's theory by modern scholars.

Theophrastus' criticisms of Plato will therefore be given a detailed and extended analysis in the concluding chapters of my essay on Plato.

2. Theophrastus' more general remarks on earlier theories of weight, supplemented by some equally valuable evidence in Plutarch, will lie at the core of my attempt in the final chapter of this first essay to reach back to the ways of thinking about weight that were current before Aristotle, and to a lesser extent Plato, drastically shifted the scope and

the direction of people's ideas, here as in other and more important ways.¹

3. The two extracts on Democritus, the first, the only attempt that we have from Aristotle or Theophrastus to present Democritus' theory free from entanglement with other theories, and the second a brief criticism of the theory, I consider in this and in the following sections of this chapter.

The problem with the earlier, and the longer, extract lies primarily in determining the immediate sense of the form in which Theophrastus presents Democritus' theory, the more so as there has recently been an attempt to change radically the sense that had traditionally been attached to the passage.

In the following sections, the problem will lie rather in tracing the precise ideological affiliation of the ideas that Theophrastus introduces, when he turns from exegesis to criticism of Democritus' theory.

'De Sensibus' 61–2

In Diels' edition of the *De sensibus* we read, cap. 61–2 (DK 68A135): ἐν ἐνίοις μὲν οὕτως εἶρη- κεν· ἐν ἄλλοις δὲ κοῦφον εἶναι φησιν ἀπλῶς τὸ λεπτόν.

διαίρειν pF.

διακριθῇ pF.

ἐν μὲν Burchard.

διαφέρει om. codex Vossianus.²

¹ Ch.XIII § 2, pp.364–83 below, esp. pp.370–8.

² Diels wrongly arrogates to himself Mullach's correction to διακριθῇ.

Bibliographical note. Throughout this chapter authors' names alone are given for the following works, all of them containing editions or translations of the relevant chapters of the *De sensibus*, and which I list here in chronological order: Henricus Stephanus, *Aristotelis et Theophrasti scripta quaedam* . . . (Parisiis,

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(i)

McDiarmid, in an article on this passage preparatory to an edition of the *De sensibus*, emends the second sentence to read:

εἰ γὰρ διακρίθην ἐν ἑκαστον κατὰ σχῆμα διαφέρει σταθμῷ, τῷ μεγέθει διαφέρειν. This he translates:

'For he says that if each one [i.e. each uncompounded body] when separated according to shape differs in weight [i.e. from others of the same shape], it differs in size.'¹

The distance that McDiarmid has to travel from the manuscript reading might perhaps be partly atoned for by the ingenuity of his argument. What cannot be so easily forgiven is that the result does not make satisfactory sense. For if weight is to be defined or determined by size, as Theophrastus tells us that it is in the first sentence which I have quoted, then the conclusion must be: not that atoms of the same shape have a different weight if they differ in size, and so presumably the same weight if they have the same size, which is the purport of McDiarmid's emendation; but that *even if* they do *not* have the same shape they are the same weight if they have the same size, and a different weight if they differ in size.

Not only is this the meaning needed: it is precisely the meaning given by the manuscripts before McDiarmid's excisions: εἰ καὶ

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1557); Ioannes G. Schneider, *Theophrasti Eresii quae supersunt opera* . . . (Lipsiae, 1818–21); Johann F.W. Burchard, *Commentatio critica de Democriti Abderitae de sensibus philosophia* . . . (Mindae, 1830); Ludwig Philippson, *Ὑλὴ ἀνθρωπίνη* . . . (Berolini, 1831); Felix Papencordt, *De atomicorum doctrina commentationis specimen primum* . . . (Berolini, 1832); Friedrich W.A. Mullach, *Democriti fragmenta* . . . (Berolini, 1843); Friedrich Wimmer, *Theophrasti Eresii opera* . . . (Didot, Parisiis, 1866); Hermann Diels, *Doxographi graeci* . . . (Berolini, 1879); Paul Tannery, *Pour l'histoire de la science hellène, de Thalès à Empédocle* (Paris, 1887), 2nd edn by A. Diès (Paris, 1930); George M. Stratton, *Theophrastus and the Greek physiological psychology before Aristotle* (London and New York, 1917). Fuller references may be recovered from the Bibliography.

¹ J.B. McDiarmid, 'Theophrastus *De sensibus* 61–62: Democritus' theory of weight' *CP* 55 (1960) 28–30. The square brackets and the words contained within them are transcribed from McDiarmid. Throughout this section, I have not thought it necessary to give internal references to McDiarmid's article. Among subsequent scholars, David J. Furley prints McDiarmid's text and finds his argument 'cogent', *Two studies in the Greek Atomists* (Princeton, 1967) 103 n.38.

κατὰ σχῆμα διαφέρει (or διαφέρει). It cannot be right to excise this second conditional particle, as McDiarmid proposes, for its removal at once makes weight seem to be dependent not only upon size, but upon shape.

If we retain διακριθῆ, with a subsidiary conditional clause intervening.

And once that is done, then we have in effect the essentials of what I shall call the traditional reading:

'If each atom were taken on its own, then even if it differs from another in shape, its weight would be dependent upon its size.'¹

(ii)

McDiarmid's attack on the traditional rendering turns initially on the use of the optative, ἂν ... ἔχειν:

'... why would the sentence be put in this form? Even if Democritus expressed his theory in such a tentative way, it is

¹ I hope that it is desirable to group together the main body of scholars in this way. The 'traditional interpretation' as I have formulated it here is common to Schneider, Papencordt, Mullach, Wimmer, Diels (if one may judge by his text and emendations, with no translation) and Brieger, *Urbewegung* 5.

F. Lortzing proposes a rather elaborate emendation, where he exploits the two readings μέγεθος ἴσον ἔχοντα σταθμῶ οὐδὲν ἂν > διαφέρει <v>· σταθμὸν γὰρ ἐπὶ μεγέθει τὴν φύσιν ἔχειν. But I think that, with this, he intends to retain what I am calling the traditional interpretation. Philippson, 135, translates without any notion of 'even if', and offers no further comment. The only clear exception to the traditional interpretation, apart from McDiarmid, is Burchard, see pp.119–23 below.

Since my main purpose in this essay is to determine the more general sense of Theophrastus' remarks, and to bring together the ancient evidence on weight as a whole, I have deliberately left aside for another occasion those *minutiora* of the text which divide the adherents of the traditional interpretation one from another: see further p.131 n.1 below.

unlikely that Theophrastus, who is reporting his theory, would do so. Throughout the *De sensibus* he regularly states the doctrines of his predecessors as simple facts, and he uses the potential optative statement—either alone or with a protasis in the optative or the indicative—when he is criticising the doctrines and showing the absurdities that would follow if the doctrines should be accepted.¹

This argument, I think, overlooks the degree of sophistication required in considering the atomic theory. It is clear that a distinction is being made between individual atoms and groups of atoms. It seems to me perfectly plausible—whether for Democritus or perhaps more likely for Theophrastus—to present a statement about an individual atom in an 'unreal' form of condition: 'if a single atom were to be taken on its own . . .'. For fairly obviously it would in practice be impossible to take any individual atom and either measure it or weigh it singly.

McDiarmid's other principal argument against a traditional reading turns on the relation between weight and shape. McDiarmid's reflections on this subject seem to me to be enmeshed in a good deal of confusion, at once conceptual, exegetical and doxographical, which I shall do my best to unravel as clearly and as briefly as I can.

(iii)

Although their readings of the sentence varied quite considerably in detail, most nineteenth-century scholars understood the sentence in roughly the same way:

'If each atom were taken on its own, then even if it differs from another in shape, its weight would be dependent upon its size.'

For my present purposes I have ventured to disregard the differences of detail and to call this the traditional interpretation.¹

An exception to this tradition was Burchard, who emended the sentence to read: ἕκαστον, εἰ καὶ κατὰ

¹ The same references as in the preceding footnote.

σχῆμα διαφέρει <καὶ κατὰ> σταθμόν, ἐπὶ μεγέθει τὴν φύσιν ἔχειν.

The explanations which Burchard provides of this, in Latin and in German, are not without their difficulty, but the intention is evidently that the subject of the whole sentence should be heavy and light, picked up from the preceding sentence, 'if heavy and light are considered each on its own, without reference to the other'; and that the conclusion should be that heavy is what is large and light is what is small; while the stipulation in εἰ καὶ . . . somehow means, 'if we take heavy and light in their everyday sense, and without reference to shape or to apparent intrinsic weight'.¹

McDiarmid confesses in a footnote that he has not actually read Burchard's work, and that he has taken note of his emendation from Mullach. In so doing, he can perhaps be forgiven for having failed to master Burchard's intentions from the portion of Latin paraphrase, which is all that Mullach quotes in his note. Consequently, McDiarmid evidently takes Burchard's emendation to mean:

¹ The Latin paraphrase runs as follows, 15:

'Si, quod quotidiano levium et gravium usu in singularibus aestimandis corporibus intelligi solet, audimus, nec mutuae harum notionum conditionis, nec formae vel ponderis proprii ratione habita, quod maius est, id plerumque etiam gravius habetur, quod minus spatiosum, idem levius; sin vero alterum alteri adiungas, sive alterum ad alterum referas (

ἐν γὰρ τοῖς μικτοῖς —*nisi forte haec etiam corrupta sunt, quod facile mihi persuaserit aliquis*), levius erit, quod plus, gravius, quod minus habet vacui.'

The German is as follows, 29–30:

'Über das Leichte und Schwere lässt sich Democritus . . . so vernehmen: Wenn man diese Begriffe in dem Sinne nimmt, den ihnen der tägliche Gebrauch giebt, ohne ihre Relativität, oder Gestalt und muthmassliches eigenthümliches Gewicht zu berücksichtigen, so pflegt man, jedes für sich betrachtet, im gewöhnlichen Leben das Schwere mit dem Grossen, das Leichte mit dem Kleinen in Verbindung zu setzen; bezieht man aber beide Begriffe auf einander . . . so ist das Leichtere das, was mehr, das Schwerere, was weniger leeren Raum in sich schliesst.'

Burchard's paraphrase has perhaps influenced Tannery's translation, 369: 'Démocrite distingue le lourd et le léger d'après la grandeur. Car, s'ils étaient absolument séparés, quelle que fût la différence des formes, la grandeur déterminerait l'effet par rapport à la balance.' Here 'heavy and light' seem to be taken as the subject of the second sentence, as Burchard wishes.

'If one atom differs from another in shape and in weight, then it differs also in size.'

This McDiarmid then criticises as follows:

'If things are characterised by shape, size, and weight and if each thing differs in both shape and weight from the thing with which it is compared, the comparison does not permit any conclusion about the relation between weight and size.'

This criticism obviously bears no relation to Burchard's original intention.

The one point which perhaps needs reply, in Burchard's interpretation, is his contention that the subject of the sentence is heavy and light, and not the atoms.

This contention is fairly obviously ruled out by the contrast, in the sentence following, with $\sigma\chi\eta\mu\alpha$, which we have been told in the sentences immediately preceding is, along with size, position and arrangement, a primary character of the atoms.¹

(iv)

However, to return to McDiarmid. To misunderstand, and thereby to misrepresent, Burchard is perhaps no great matter. What is less venial is that McDiarmid then attempts to apply the same criticism to other nineteenth-century scholars, who make up what I have called the traditional interpretation. Of these interpretations McDiarmid writes:

'Taken in any of these ways the clause is open to the objection already raised against the reconstruction of Burchard. If the atoms differ in shape as well as in size and weight, the sentence does not establish the relation between size and weight, since the possibility has not been excluded that difference in weight is due to difference in shape rather than in size.'

¹ This will be so, even if the first clause of the second sentence is taken to introduce atoms only indirectly as it were. Thus Stratton translates, 121: 'If we were to divide each substance into its <atomic> units'. There is the same approach in Samuel Sambursky, *The physical world of the Greeks* (London, 1956) 120: 'If any object is decomposed into its parts'. It seems to me in fact more natural to take $\epsilon\kappa\alpha\sigma\tau\omicron\nu$ as referring directly to an atom. Cf. p.225 n.2 below.

'If the atoms differ in shape as well as in size and weight . . .'. Who holds this interpretation? Not the scholars whom McDiarmid has listed, for they hold what I have called the traditional interpretation. On this interpretation, the weight of an atom is said to be proportionate to its size. In this main clause of the sentence, no comparison is expressed between one atom and another.

What is more, if we do introduce an external comparison, by extending the comparison contained in σχῆμα διαφέ- ροι, the result is not what McDiarmid's criticism would require. For if we begin a sentence by saying 'even if one thing is different from another in a certain way', then I think we are most likely to continue, 'it is nonetheless the same as it in some other way'. In this instance:

'Even if one atom differs from another in shape, it will be the same weight if it has the same size.'

It is true that if we are then drawn to extend the comparison still further, we may well add:

'Even if one atom differs from another in shape, it will be the same weight if it has the same size, *and* a different weight if it differs in size.'

What is not so plausible, it seems to me, and what is certainly not a necessary consequence of the traditional interpretation, is that we should choose to extend the implied comparison to express *only* a difference of weight and size:

'Even if one atom differs from another in shape, . . . it will be a different weight if it differs in size.'

How then has the interpretation arisen which McDiarmid criticises: 'if the atoms differ in shape as well as in size and weight . . .'? It cannot, I think, be simply a diffusion of what McDiarmid (wrongly) supposes Burchard's interpretation to be, for McDiarmid realises that Burchard is alone in writing,

εἰ καὶ κατὰ σχῆμα διαφέρου <καὶ κατὰ> σταθμόν. The truth is, I think, that McDiarmid has confused the traditional interpretation with his own,

and has himself conflated part of one with part of the other. To the traditional interpretation of shape, 'even if one atom differs in shape (*sc.* from another)', McDiarmid has tacked on his own conclusion, 'it differs in weight if it differs in size'. He forgets that to achieve this rendering he will have had to emend the sentence to read, *σταθμὸν ἂν ἐπὶ μεγέθει τῇν φύσιν ἔχειν*. Once again therefore the bogey which McDiarmid criticises is entirely of his own making.

(v)

Again, however, we might be inclined to forgive McDiarmid for misunderstanding, and thereby misrepresenting, the opinions of others, if his own interpretation made sense. But even when he turns from criticism to reconstruction McDiarmid's confusion is not at an end. After the criticism which I have quoted of the traditional interpretation, McDiarmid at once turns to provide the ideological foundation of his own interpretation. He writes:

'If shape is brought into an argument for the weight-size relation, the argument should be: if two atoms have the same shape but differ in weight and size, weight must be related to size and not to shape.'

I think the radical confusion in this idea lies in McDiarmid's assumption that we have to do here with an argument. But to make my point clear it will be best, I think, if we pause to consider what in fact the possible combinations of shape, size and weight may be.

1. One atom could differ in shape, size and weight from another.
2. It could have the same shape, size and weight as another.
3. It could have the same shape, and differ in size and weight.
4. It could have a different shape, and be the same in size and weight.

No other combinations are possible, if size and weight are to go hand in hand.

The *first* combination is the one which McDiarmid identifies (wrongly) with Burchard and with the traditional interpretation, and which he criticises accordingly:

'If the atoms differ in shape as well as in size and weight, the sentence does not establish the relation between size and weight, since the possibility has not been excluded that difference in weight is due to difference in shape rather than in size.'

The *second* combination would presumably be open to an equivalent objection:

'If the atoms are the same in shape as well as in size and weight, the sentence does not establish the relation between size and weight, since the possibility has not been excluded that similarity in weight is due to similarity in shape rather than in size.'

McDiarmid himself chooses the *third* combination, on the ground that:

'If two atoms have the same shape but differ in weight and size, weight must be related to size and not to shape.'

He apparently does not consider that an equivalent argument could result from the *fourth* combination:

'If two atoms differ in shape but have the same weight and size, weight must be related to size and not to shape.'

This *fourth* combination is precisely what is provided by the traditional interpretation, if we extend the comparison implied in the clause *ἐὶ καὶ* in the way that I have argued is the more natural:

'(Even) if an atom differs from another in shape, its weight is related to its size—and so it will be the same weight as another atom if it has the same size.'

This *fourth* combination requires much less emendation of the manuscripts than does the *third*. There is also a sense in which, it seems to me, it is perhaps preferable conceptually. For it concludes with a positive statement: an atom is the *same* weight as another if it has the *same* size. This seems to me a more natural conclusion than that an atom *differs* in weight from another if it *differs* in size. Indeed if we are presented with the statement that 'if two bodies differ in weight they differ in size', we would, I think, need, or at least find it natural, to conclude that 'they will therefore have the same weight if they have the same size'.

If we do conclude the argument in this way, then there is a further disadvantage to McDiarmid's interpretation. For if we are thinking of atoms of the same shape, as on McDiarmid's formulation we are, then this conclusion at once leads to the *second* combination, to atoms which have the same shape, the same size and the same weight, and where therefore weight would seem to be related either to size or to shape. What we need to conclude with is that:

'Even if atoms differ in shape, they will have the same weight if they have the same size, or a different weight if they have a different size.'

And that of course is precisely the implication of the traditional rendering.

(vi)

Now it is important, I think, to realise what has happened here: the assumption of my last two paragraphs has been that we are entitled, or at least encouraged, to move from one stage in an argument to the more general statement of principle or theory which such an argument might conclude with. This distinction, between argument and conclusion, is essential to a consideration of McDiarmid's interpretation. For the assumption that underlies McDiarmid's interpretation is that we have to do here with an argument: with the statement of some circumstance which will make it plausible for Democritus to define heavy and light in terms of size. This circumstance has to be one which does not cover all instances of the relation of weight to size, but one in

which it is made especially apparent that weight and size are related.

Now the immediate disadvantage, it seems to me, in looking for such an argument in the present context lies precisely in the fact that by its very nature such an argument does not deal with all circumstances concerned with weight and size, but only with some of them. It will need to be completed therefore: from the statement of particular circumstances which make it especially apparent that weight and size are related, we will need to conclude to the same relation in all circumstances, even those where the particular circumstances do not make the relation especially apparent. But of such further statement there is of course no trace in Theophrastus.

What we must do in fact, on McDiarmid's interpretation, is treat the opening sentence, εἰ γάρ, as containing the argument enlisted in its support.

Now whether the two sentences are to be taken in this way or not turns on the sequence of thought conveyed by the connecting particle εἰ γάρ that we are to be treated to an argument designed to support, or to justify, the preceding definition. But we could of course equally well expect to be given some explanation or elaboration of the definition. Which in fact do we have?

The peculiarity of the Atomists' theory of weight, as we already know from Aristotle, is that there is not one theory, but two: one theory for single atoms, where weight is defined in terms of size, and another theory for compound bodies, where weight depends on void. Since he begins by the simple statement, μικτοῖς...

This in itself is perhaps enough to indicate that γάρ of justification. What we are being given is not an argument in favour of the definition, but a qualification and an explanation of it:

'Democritus thus defines heavy and light . . ., *for* in the case of single atoms . . ., *whereas* on the contrary (οὐ μὴν ἀλλὰ ... γε) in the case of compound bodies . . .'

(vii)

This same orientation, I suggest, an expectation not of argument but of explanation, puts us in the right frame of mind to appreciate the words which follow immediately the clause introduced by εἰ καὶ κατὰ σχῆμα διαφέρουσι (or διαφέρει).

In the chapter immediately preceding, Theophrastus has told us that Democritus explains the nature of sensibles by the size or shape of atoms, or by their arrangement and position, cap. 60 (DK 68A135): καὶ θέσει διορίζει.

'Democritus does not account for all <the sensibles> in the same way: some he explains by the sizes <of the atoms>, others by their shapes, others he explains by their position and arrangement.'

Two of these factors are fairly obviously irrelevant to the present circumstance.

1. If we are to consider the intrinsic property of a single atom (τάξις), is clearly irrelevant.
2. The position of an atom (θέσις), it is fairly clear, will be equally irrelevant, since position is again in effect a material factor only when at least two atoms are considered together.

If weight is to be introduced as a function of one of the primary characteristics of the atoms, it can therefore be related only to shape or to size. Since Theophrastus tells us that Democritus' intention is in fact to relate weight to size, it therefore makes sense explicitly to single out shape as what we might call an irrelevant variable: 'whatever the shape of an atom, its weight is dependent upon its size'.

Now it is at this point, I suggest, that we particularly appreciate the formula: εἰ καί

'I will love you, even if you hate your mother.' The implication is obviously something like: 'And of course if you like your mother, I shall still love you, or even love you all the more'. Logically, the force of the formula is that 'I shall love you whether or not you hate your mother', but humanly, as it were, one element in the 'whether or not' is accounted as more likely to be realised, or as more relevant to the situation, than the other.

So too in this context. If weight is to be defined by size, then two atoms that are the same size will have the same weight. Now obviously if the two atoms are also of the same shape, there will be no additional factor that could disturb this equivalence. It is only if the two atoms are a different shape that we might wonder: will they still be the same weight? And it is on this point that we need reassurance, as it were:

'Even if two atoms differ in shape, they will have the same weight if they have the same size.'

Thus there are two elements in the sentence which Theophrastus attaches to the Atomists' statement of weight in terms of size.

1. The definition is true only of individual atoms, not of compound bodies.
2. The alignment of weight and size holds good, despite any difference of shape.

Both elements act as a qualification or an explanation of the definition, and not as an argument in its support.¹

¹ I advance this argument without meaning to exploit any difference between εἰ καί merely represents the fulfilment of the condition as immaterial, without conveying any effect of climax' (*Greek particles* 299ff.), seems to me to match exactly Theophrastus' meaning.

(viii)

This approach clarifies the structure and the relation of the two sentences I have quoted.

The two features added as qualification or as explanation of the definition are expressed wholly in the two protases:

βαρὺ μὲν οὖν καὶ κοῦφον τῷ μεγέθει διαιρεῖ Δημόκριτος .

At the same time, the expression of the two protases creates a certain tension in the apodosis.

1. In the first conditional clause, Theophrastus chooses to speak of individual atoms in the singular (οὐ μὴν ἄλλ' ἐν γε τοῖς μικτοῖς) . This distribution of singular and plural is possibly not essential to the thought, but it is a natural and obvious way of expressing the distinction.

Indeed, not only does the distinction between singular and plural provide a natural form of contrast: the distinction is directly related to Theophrastus' expression of the atomic theory. The size of an atom (if we are not too scrupulous about more modern notions of relativity) can be considered as a character intrinsic to the atom and may therefore be expressed in terms of a single atom, with no external comparison. But the weight of a compound body is expressed by Theophrastus in terms of there being more void in one compound body than in another, so that on this formulation an external comparison is unavoidable.¹

¹ Although the use of βαρύτερον: one body is 'heavier' or 'lighter' <than another>. There is an equivalent ambiguity in Aristotle's initial statement of the atomic theory, *De caelo* iv 2, 309a10–11, where the ambiguity is again resolved in favour of an external comparison, 309a29–30; cf. p. 101 n.1 above.

2. On the other hand, in the second conditional clause, the irrelevancy of shape is expressed, at least by implication, in terms of more than one atom: 'even if one atom differs (*sc.* from another) in terms of shape'.

This distribution of singular and plural, between the first and second protasis, affects the sense of the words which have to act as apodosis to both conditional clauses. The expression of the first protasis requires that the apodosis should speak of a single atom, while the second protasis requires that the apodosis should continue the comparison of one atom with another.

1. Formally, the apodosis is most simply taken as following the requirement of the major and introductory protasis, with $\epsilon\chi\epsilon\iota\nu$: 'if each atom is taken on its own . . . then the weight <of each atom> is related to its size'.
2. But informally and by implication the apodosis can be taken to follow the sense of the second protasis, if we allow for completion in terms of more than one atom: ' . . . even if one atom differs in shape (*sc.* from another), its weight would be dependent upon its size (*sc.* so that if one atom has the same size as another, it will have the same weight, and if it differs in size it will differ in weight)'.

I have already remarked on the need to give priority to the statement of similarity, if we are to provide the natural and appropriate contrast to the expression: 'even if it differs . . .'.

It is from singling out one element only in this informal completion of the apodosis that McDiarmid is led to confuse the traditional interpretation with his own: 'if the atoms differ in shape as well as in size and weight . . .'. From this, from missing the precise significance of 'even if', and from making a false assumption about the nature of the introductory $\epsilon\iota\ \gamma\acute{\alpha}\rho$, McDiarmid's troubles arise.

As it is, the sentence provides a perfectly understandable qualification, and explanation, of the definition of heavy and light as dependent upon size. The definition applies to individual atoms only; and it applies to them irrespective of their shape. Formally, the conclusion of the sentence does no more than repeat the

definition: the weight of an atom is dependent upon its size. Informally, the expression of the second protasis encourages, or at least allows, the implication:

'If an atom is the same size as another, it will have the same weight, and if it differs in size it will differ in weight.'

Conclusion

I paraphrase therefore:

'Heavy and light then. These Democritus distinguishes by size. The idea is that if each individual <atom> were taken separately on its own, then even if it differed <from others> with reference to shape, in terms of weight its nature would be dependent upon its size, <so that if it has the same size as another atom it will have the same weight, and if it differs in size it will differ in weight>.

'This is not quite so however as far as mixed bodies are concerned. Of these, he says, the lighter would be the one containing the more void. The heavier body conversely would be the one containing the less void.

'He so expresses himself in a number of places. Elsewhere he says simply that what is finely textured is light.'¹

¹ Theophrastus, *De sensibus* 61–2, quoted at the beginning of the chapter. For the final two sentences of the translation see below p.256 n.3.

It will be apparent that I have left aside in my analysis many points in Theophrastus' text which cry out for a more detailed investigation: the emendation of ἐν ἐνίοις μὲν <οὖν> (Diels).

These questions highlight the need for a new critical edition of the *De sensibus*, to match the editions already existing of the *De lapidibus* (ed. D.E. Eichholz, 1965) and of the *De igne* (ed. V. Coutant, 1971), and also for critical studies of Theophrastus' language, such as that pioneered by L. Hindenlang, *Sprachliche Untersuchungen zu Theophrastus' botanischen Schriften* (Strassburg, 1910).

I had myself hoped to meet the need for a critical edition; I regret that I have

(footnote continued on next page)

§ 2—

Criticism of the Theory: The 'Necessity' of Movement

When Theophrastus turns to criticise Democritus' theory of weight, after an account of other *sensibilia* in the atomic theory, he writes as follows, *De sens.* 71 (DK 68A135): τῆς φορᾶς, ὥστε μᾶς τινὸς ἂν ὕλης εἴη καὶ τῆς αὐτῆς φύσεως.

As I have noted, the difficulty here, such as it is, lies not in determining the immediate sense of the words, but in appreciating their ideological affiliation, and the significance of this for our enquiry.

The immediate sense of the words I paraphrase as follows:

'And what is more, since Democritus defines what is heavy and light by the sizes <of the atoms>, it necessarily follows that all the <four> simple bodies <i.e. the cosmic elements, earth, air, fire and water> have an identical impulse of movement, so that they would <all> be <made> from a single material principle, and <would all be> of one and the same nature.'

The obvious ideological affiliation of these sentences lies with the passage that I quoted and paraphrased earlier from the first book of the *De caelo*, where Aristotle complains that if the atoms are all heavy absolutely—for that, I have argued, is the natural implication of the passage—then there can be nothing that is light absolutely, and *vice versa*.¹

In the course of this criticism, Aristotle makes broadly the same two points that we find repeated in Theophrastus.

1. The atoms have all a single *physis*, τὴν δὲ φύσιν εἶναί φασιν αὐτῶν μίαν (cap. 7, 275b32–276a1).

(footnote continued from previous page)

so far been kept from realising this project. In the absence of a critical edition, I have judged it best, in the present work, to content myself with seeking to establish what I believe are the main bones of the text, especially against McDiarmid's eccentric reinterpretation, while fully realising that later research may require a different reading of some details of the text.

¹ *De caelo* i 7, 275b29–276a6, pp.11–15 above.

2. The atoms have all a single movement $\tauούτων δὲ ... ἀναγκαῖον εἶναι τὴν αὐτὴν κίνησιν$ (276b1–2).

There remain two particular differences, in the expression and in the sequence of thought: these need to be traced with some care.

'The Simple Bodies'

The most obvious difference between the two passages is that Theophrastus specifies the object of his criticism as $τὰ ἀπλᾶ πάντα$, 'all the simple bodies', which must mean the four cosmic elements, whereas Aristotle writes in effect of the atoms, since he introduces the atomic theory as providing a universal material principle which is 'divided by void' and 'defined by shapes' (275b29–32).¹

(i)

At first, this may seem a significant divergence, for the distinction between the atoms and the atomic equivalents to Aristotle's own four cosmic elements I have argued is crucial to the criticism that Aristotle makes of the atomic theory later in the *De caelo*.

The atoms, I have argued, according to Aristotle move always

¹ Albert Goedemeckemeyer, *Epikurs Verhältnis zu Demokrit in der Natur-philosophie* (Strassburg, 1897) 109–11, takes 'the simples' to be the primary qualities ('die einfachen Sinnesempfindungen'), although this obliges him to emend $τῆς διαφορᾶς$. Albert Rivaud, *Le problème du devenir et la matière dans la philosophie grecque depuis les origines jusqu'à Théophraste* (Paris, 1906) 166 n.384, alters this to 'the atoms'. This seems also to be the meaning intended by Diels, in his *Index, Dox.* s.v. (he quotes Aet. i 12.5; cf. Arist. *De caelo* iii 4, 303a12).

Although this reading of the text would bring Theophrastus' criticism even more closely in line with that of Aristotle, I prefer myself to suppose that in a passage of criticism the expression will have the meaning which it regularly has elsewhere in the writings of Aristotle and of Theophrastus. See Bonitz, *Index Aristotelicus* 76b15–19; for the use of the adjective without a noun ($τὰ ἀπλᾶ$) and elsewhere (*De caus. pl.* vi 3.3; *De odor.* 1 and 6).

in a single direction, and in that sense may be reckoned therefore as approximating to the possession of absolute weight, while the elemental bodies that are formed from the atoms, earth and fire, which should have absolute weight, prove not to do so, since there must always be a quantity of fire which will have more atoms, or more atomic solid, and so will be heavier than a certain quantity of earth.¹

(ii)

However, this discrepancy between Theophrastus' criticism and the account that I have offered of the criticisms that are made by Aristotle is more apparent than real.

Theophrastus is able to ignore the distinctions that I have stressed between atoms and bodies which are made from the atoms, because he specifies *all* the simple bodies as having the same 'impulse of movement', and the same material principle therefore.

The point is that according to Aristotle material bodies, for the Atomists, whether atoms *or* the bodies formed from them, can have movement in only one direction. This is the reason why the atoms, whichever of the four cosmic elements they may be supposed to constitute or to represent, cannot produce any differences of movement that are not simply the expression of the size and the number of atoms. For since fire and earth, on the atomic theory, are made from the same material substance Aristotle supposes that they must both move in the same direction, and with the same speed for equal quantities. The larger quantity will be heavier therefore than the smaller quantity—however much the difference of quantity, in compound bodies, may be disguised, as it were, by the addition of void—whichever of the two quantities is supposed to represent earth or to represent fire.

This is the same therefore as saying that *all* the four cosmic elements have the same 'impulse of movement', if we take this expression to mean, or at least to include, as I think it must, movement in a single direction. For Aristotle's point is precisely that on the atomic theory it is impossible to distinguish one element from another in terms of weight: the movement of *any*

¹ See especially ch.I § 3–5, pp. 15–40 above.

element, if it is determined by the quantity of atomic solid, will, in a certain quantity, outweigh the movement of any other element, irrespective of whichever element is supposed to have absolute weight, or to have relative weight. *All* the elements therefore have movement in the same direction: and in so far as their movement is determined by the size and by the number of atoms there can therefore be no distinction between them of the kind that Aristotle holds must characterise the behaviour of elements with relative and with absolute weight.

In short, the only difference that Aristotle holds is able to obtain between different elements in the atomic theory, namely an increase of speed for the greater quantity, is a difference that in Aristotle's own theory would obtain between the parts of a single element.

From this point of view therefore I conclude that Aristotle's argument that earth cannot have absolute weight, since fire in a certain quantity will be heavier than earth, and his argument that air in a certain quantity would move downwards more quickly than earth, are faithfully reflected, and summarised, in Theophrastus' claim that *all* the four elements, in the atomic system, must have a single nature and the same 'impulse of movement'.

(iii)

In writing of elements that have relative weight, I have assumed that we may include the criticisms of the fourth book, as well as the criticism of the first book of the *De caelo*, as being implied in the *De sensibus*.

The two points of similarity that I have noted between the passage from the first book of the *De caelo* and the criticism which Theophrastus makes of Democritus incline me to believe that it is perhaps the argument of the first book which Theophrastus has primarily in mind: the atoms will be either heavy absolutely or light absolutely, and if they are the one then they cannot be the other.

Strictly speaking, however, it is only in the criticism of the fourth book that Aristotle specifically broadens his criticism to include the comparison of elements that have relative weight, with each other and with elements that have absolute weight. We shall need to include the arguments from the fourth book therefore if

we are to provide a complete Aristotelean prototype for the argument that *all* the elements have a single 'impulse of movement'.

It is true that in omitting any mention of void in his criticism Theophrastus avoids the particular elaboration of Aristotle's final argument in book four, where void and plenum are taken as coexistent principles, representing respectively fire and earth.

But apart from this elaboration there is no ideological barrier to combining the criticisms from both books. The general message of the criticisms in book four is the same as that of the argument in book one: bodies which move all in the same direction, and with the same speed for equal quantities, cannot provide for a distinction between two elements with absolute weight, nor for the distinction between an element with absolute weight and an element with relative weight.

I conclude therefore that Theophrastus' criticism correctly reproduces the essentials of Aristotle's criticism of the Atomists in both the first book and in the fourth book of the *De caelo*. The difference in the immediate subject of the criticism, '*all* the simple bodies' instead of the atoms, is, from the general point of view of Aristotle's criticism of Democritus, and of his classification of the atoms, a difference of presentation, with no divergence of ideology. Here as elsewhere in the *De sensibus*, Theophrastus shows that freedom of manoeuvre and expression which comes from a total understanding of the principles of Aristotle's criticism.

(iv)

Very briefly therefore I return to the claim made by Liepmann, which I noted in an earlier chapter, that in this passage Theophrastus treats the atomic system as providing only for bodies which have relative weight, as Aristotle also does, according to Liepmann, in the passage from the first book of the *De caelo*.¹

In Aristotle's case, I have argued, the assumption is just the opposite. Aristotle's argument is that if the atoms have movement all in a single direction then they will be *either* heavy absolutely *or* light absolutely: the point is not that they are neither, but that they cannot be both.

¹ Liepmann, *Mechanik* 41, p. 13 above.

This will also be true for Theophrastus, if we interpret his criticism in the light of the passage in Aristotle, as I have suggested that we should.

Even if we extend the implication of Theophrastus' criticism to include the arguments which Aristotle brings against the Atomists in the fourth book of the *De caelo*, it in no way follows that in Democritus' system, according to Theophrastus, 'Alles wird *relativ* schwer'.

Rather the contrary. It is true that no individual body—no privileged grouping of the atoms—will be heavy absolutely. But this is because *all* the elements have a single nature and a single 'impulse of movement'. They will therefore approximate, taken in their totality, to the possession not of relative, but of absolute weight.

Matter and Movement

A second and perhaps more serious error in the interpretation of this passage lies in Bailey's assertion that according to the 'suggestion' of Theophrastus 'weight' for Democritus 'is the cause of motion'.¹

If it were true, this assertion would call into question much of the account that I shall give of earlier ideas about weight in the succeeding chapters of this essay.

At the same time, Bailey's claim symptomises what I believe to be the most radical—although also one of the most obvious—errors in the modern interpretation of the *De sensibus*: the failure to distinguish exegesis and criticism.

(i)

If we take only the first two clauses of the sentence which I quoted at the beginning of this section, then it is fairly plain, as Brieger had noted, that the opening clause, τό γε βαρὺ καὶ κοῦφον ὅταν διορίζη τοῖς μεγέθεσιν, alone purports to record

¹ *Greek Atomists* 130–1. Bailey adds passages from Cicero and Simplicius. The passage from Cicero, I shall argue later, he has also misunderstood, pp. 245–8 below. In adducing the evidence from Simplicius, Bailey fails to distinguish properly between the movement of atoms in the void and the distinction of heavy and light by the distribution of atoms between centre and circumference in the formation of a cosmos: see below ch.V, pp. 158–61.

Democritus' own view. The words which follow, *τούτων δὲ ...ἀναγκαῖον εἶναι τὴν αὐτὴν κίνησιν* (276a1–2).¹

This is confirmed by the fact that in a number of places elsewhere, including a passage later in the *De caelo*, Aristotle argues that the origin and the nature of the atoms' movement (*ᾧθεν ἢ πῶς, διὰ τί καὶ τίνα*) were not specified by Democritus.¹

Fairly plainly, therefore, the notion that the atoms move in a single direction is Aristotle's own inference from the fact that the atoms have 'all the same nature' like 'gold in separate pieces' (275b31–276a1).

(ii)

At the same time, the relation of the final clause to the preceding clause in Theophrastus' criticism betrays a significant difference between Aristotle and Theophrastus in the connection of thought.

Aristotle argues that if the whole is not continuous, but is divided by void, then all things must have the same movement (275b29–31). There is the same sequence of ideas in the sentences immediately following. If the atoms are defined by their shapes, and if they have all the same nature (*φύσις*), 'as though each were made from a separate piece of gold', then they must therefore have all the same movement (275b31–276a2).

On the other hand, Theophrastus argues that the simple bodies, for Democritus, must have all the same 'impulse of movement', and that therefore (*φύσις*).

Thus premiss and conclusion would appear to be reversed in the two accounts.

1. For Aristotle, the nature of the atoms is identical, and therefore they have movement all in the same direction.
2. For Theophrastus, the movement of the 'simple bodies' is the same, and therefore their nature is identical.

¹ Brieger, *Urbewegung* 6, cf. 'Urbewegung' 588–9.

² References and argument, pp.237 and 261–2 below.

(iii)

The immediate reason for this apparent reversal of premiss and conclusion lies in the distinction that I have already noted between atoms and the four 'simple bodies' as the subject of the criticism.

1. Aristotle argues from the nature of the atoms being single to the necessity of their movement being one.
2. Theophrastus argues from the identity of movement in the cosmos to the identity, not of the atoms, but of the cosmic elements.

From this point of view, Aristotle's argument acts as a premiss to the argument which Theophrastus adopts: (i) because the atoms have a single nature, therefore their movement is the same (Aristotle's argument); (ii) <because the nature and the movement of the atoms is the same> it follows that the cosmic elements <which are formed from the atoms> have a single movement, and a single nature therefore (Theophrastus' argument).

(iv)

At the same time, what I have called the Aristotelean premiss to Theophrastus' argument does find a place in the passage from the *De sensibus*: it is represented by the first clause in Theophrastus' criticism, that heavy and light are defined 'by sizes'.

In the context of the *De sensibus*, this clause acts as a summary of the account that has already been given of Democritus' theory. But ideologically the definition of weight by size repeats in effect Aristotle's point that the atoms have a single nature, with no distinction therefore (in the first book of the *De caelo*) between an element which is heavy absolutely and an element which is light absolutely. The point is that on the Aristotelean theory a difference of size cannot add up to a difference of nature: if the only difference of weight between the cosmic elements lies in their being constituted from larger atoms or smaller atoms, then there can be no more difference of nature between the four elements than there is between one piece of gold and another.

Theophrastus' assertion that heavy and light are defined only by size is equivalent therefore, from the point of view of Aristotle's philosophy, to the assertion that the atoms have all the same movement, as separate pieces of gold would have.

(v)

In a rather more oblique fashion, this same equivocation between the atoms and the four cosmic elements finds a place in Aristotle's criticism.

The conclusion that the atoms have the same movement Aristotle illustrates by the behaviour of earth and fire, i 7, 276a2–3:

πάντα πῦρ καὶ σπινθήρ εἰς τὸν αὐτὸν τόπον.

When in the following sentence Aristotle concludes that no 'body' (οὐθὲν ... τῶν σωμάτων 276a5) therefore can be light absolutely, if everything has heaviness, or heavy <absolutely> if everything has lightness, it is no longer possible, nor is it really necessary, to know whether the 'bodies' in question are atoms or the four cosmic elements. The 'grouping' of atoms, even their conjunction with larger or smaller quantities of void, cannot, for Aristotle, suffice to establish any difference in direction of movement, for the atoms or for the elements, since the atoms, and the elements therefore, have been condemned to the possession of a 'single nature'.

Thus while the sequence of thought varies, in Aristotle and in Theophrastus, the content of their criticisms is virtually the same. While Aristotle argues from the atoms' having a single nature, and movement therefore in a single direction, to the absence of any difference between heavy and light among the elements or among the atoms (depending upon the precise reference of σωμάτων), Theophrastus argues with precisely the same assumption but in the reverse direction. The absence of any distinction in weight among the atoms, other than that of size, leads to movement in the same direction, and to a single nature therefore, for the four 'simple bodies'.

(vi)

If in the light of this analysis we return to Bailey's interpreta-

tion we can, I think, see at once how hollow that interpretation is.

In both Aristotle and in Theophrastus the 'necessity' by which the atoms, or the elements, have movement in a single direction is presented as criticism and not as exegesis.

1. For Aristotle, movement in a single direction follows from the atoms' having a single nature.
2. For Theophrastus, movement in a single direction follows from the use of size as sole criterion of the difference between heavy and light, since size cannot establish any difference of nature between the atoms or between the elements.

In *neither* case is the 'necessity' by which the atoms, or the elements, move all in the same direction offered as a direct statement of the original theory.¹

Conclusion

(i)

Theophrastus repeats Aristotle's two points that in Democritus' system there is a single material substance, and that for Democritus there can be movement in only a single direction.

There is the difference that Theophrastus speaks of the cosmic elements, where Aristotle speaks initially of the atoms. This in no way falsifies the substance of Aristotle's criticism, though it leads to a difference in exposition, since while Aristotle argues from the nature of the atoms to the identity of their movement Theophrastus argues from the identity of movement to the identity, not of the atoms, but of the elements.

(ii)

Theophrastus' criticism of Democritus in no way implies that 'everything' in Democritus' world has relative weight. For Theophrastus, as for Aristotle, the 'single' material substance of the atoms, and of the elements, will approximate to the possession of

¹ Note especially ἀνάγκη in Theophrastus, *De sens.* 71 (DK 68A135).

absolute weight, precisely because it has movement always in the same direction.

Still less is it true that Theophrastus takes Democritus himself to have offered weight as cause of movement in a single direction. This belief arises from a misinterpretation of the passage in the *De sensibus*, and more generally from a misunderstanding, or neglect, of the division of material in Theophrastus' doxography. The later passage in the *De sensibus* is plainly offered not as a direct statement of Democritus' theory, but as a critical inference that Theophrastus, under the influence of Aristotle, has himself added to the theory.

§ 3—

Criticism of the Theory: 'Physis' and 'Hyle'

A Change in Terminology

There remains one feature in the criticism I have quoted from Theophrastus that can properly be viewed only from a rather broader perspective.

Whereas Aristotle, in the first book of the *De caelo*, writes of the atoms as having 'a single nature' (ἓλης εἷη καὶ τῆς αὐτῆς φύσεως).

There is here both an historical and an ideological distinction, marked by the conjunction of a word, *physis*, which is used both by Aristotle and by the Presocratics, if in a different connotation, with a term which in its philosophical usage is exclusively and specifically Aristotelean, *hyle*.

(i)

Historically, as I shall seek to show more fully in the final chapter of this essay, the 'nature' of a material body in the thinking of philosophers of the fifth century was expressed primarily by the intrinsic nature and powers of the stuff that a thing was made of.

From this point of view, part of the way in which the atomic system is presented in the passage from the first book of the *De caelo* I believe represents closely enough the original fifth-century

conception, as it was adopted by Democritus. The comparison of the atoms with pieces of gold can hardly not have been influenced by Plato's use of gold at one point in his description of 'the third *genos*' in the *Timaeus* (50A–B). Even so, its use here rightly directs attention to the material from which the atoms are made, to its uniformity and perhaps also—the additional feature which I suspect may be intended by the comparison with gold—its density and solidity. This notion of a single uniform material substance, and especially one noted for its density and solidity, would seem to answer closely enough to what we know of the original fifth-century conception of the atoms.¹

(ii)

A radical departure from Presocratic ways of thinking made by Aristotle lies in his notion of 'nature' or material substance as defined by the movement of a body in a particular direction, and its coming to rest in a particular place, as against the earlier conception whereby the identity of an object lies not primarily in its behaviour, but in the qualities or powers intrinsic to the stuff from which it is made.

Thus for the Atomists themselves the movement of the atoms, I suspect, will have stemmed from, or will have been associated with, the alternative factor in the description which Aristotle supplies for the atoms, of 'the whole' (τὸ πᾶν)—a term that can be paralleled in a number of philosophical fragments from the fifth century—as 'divided by void' (275b29–30).

From this point of view, the movement of the atoms will have been a consequence at once of the existence of void, and of the general association in the fifth century of unity with immobility, and of movement with separation and plurality.²

¹ For reports on the 'hardness' or 'solidity' of the atoms, as a reason for their indivisibility, see below p.245 n.1.

² Aristotle's main account of the various senses of *physis*, and the definition of *physis* that I have in mind as ἀρχὴ κινήσεως, is given in *Physics* ii 1–2, 192b8–194b15, esp. ii 1, 192b20–3. This definition is repeated in the *De caelo*, i 2, 268b14–16 and iii 2, 301b16–22.

There is of course a difference between the *physis* of animate bodies, which is Aristotle's primary, though not his sole, preoccupation in the passage I have cited from the *Physics*, and the *physis* of elements, which will alone provide for movement always in a specific direction.

(iii)

This would explain the divergence over the direction of movement.

1. Originally, the atoms are in movement because they are separated from one another in the void: but from the point of view of the fifth century there is nothing in this circumstance to determine the movement of the atoms in a specific direction.
2. For Aristotle, on the contrary, movement in a specific direction is a direct expression of material substance and of the 'nature' of a thing. The atoms are made all from the same material, they have the same 'nature', and so far as Aristotle is concerned they 'must' therefore have movement all in the same direction.

In this way, Aristotle's conception of the 'nature' of material substance leads him to add movement in a specific direction as a 'necessary consequence' of the atomic philosophy, although by so expressing himself he at once implies that this was not an original feature of the system.

The point is that for the Atomists movement, but not movement in any specific direction, is a consequence or accompaniment of plurality and diversity, whereas for Aristotle movement, and movement in a specific direction, is a direct expression of the 'nature' of the individual body, so that if this 'nature' is the same for several bodies then necessarily they must have movement all in the same direction.

(iv)

For Theophrastus, as for Aristotle, the cosmos in fact exhibits movement in four directions, or at least to four regions of the cosmos, corresponding to the four cosmic elements, and to the distinction between heavy and light, in both an absolute and a relative sense. It is the failure to provide for these differences of movement that is the fundamental reason for Aristotle's rejection both of Democritus' and of Plato's theories of weight, as allowing for natural movement in only a single direction.

It is true, Aristotle does believe that there is a single underlying material principle, for otherwise, he supposes, the elements could not be transformable, as he believes that they must be, and are seen to be. But this primary material principle can be distinguished from the four elements only abstractly. It has no independent existence, or rather, it is not itself characterised by any specific form of weight, nor therefore does it have movement, nor movement in any specific direction. Movement in a specific direction attaches, in Aristotle's system, not to the primary underlying material principle, but to each of the four elements.

It is true therefore that for Aristotle there is in one sense a single underlying material principle, *hyle* (e.g. *De caelo* iv 4, 312a12–21). But from another point of view there has to be a separate *hyle* for heaviness and lightness and for each of the four elements (iv 5, 312a22–b2). From this point of view the presence of a single material principle, *hyle*, in the system of Plato or of Democritus is reckoned as a sufficient refutation of their system (iv 5, 312bf19–32).

(v)

Thus from the point of view of Aristotle or of Theophrastus, the fallacy in the atomic theory is to have supposed that there can exist as the fundamental material principle of the universe a single separate substance which is characterised by weight and which must therefore have movement in only one direction. The presence of such a substance at once pre-empts the possibility of there being any real distinction in weight or in direction of movement among the 'elements' which might be supposed to derive from, or to be made out of, this single substance.

For according to Aristotle's principles the elements could not be characterised as individually, and independently, having one of the two opposite forms of relative or of absolute weight, if the underlying material from which the elements were formed were itself to possess weight, and movement.

In such a system there could be no distinction between the four cosmic elements and the composite substances that are made from them. In Aristotle's own system, the weight of wood or of lead is determined by the proportion of each of the four elements which go into the making of wood or of lead. There is therefore

no new expression of weight in composite bodies: only a rearrangement and a combination of the weight of the four 'simple bodies'. So too, in the atomic system, as seen by Aristotle, if the four elements are made from a single substance which itself has weight, and therefore movement, then they can do no more than express in their behaviour a larger or a smaller proportion of the weight—the *one* kind of weight—exhibited by the primary substance that they are made from.

It is this criticism that Theophrastus summarises in his charge that, for the Atomists, the four simple bodies must have all the same 'impulse of movement', and that they must therefore have all a single material principle (φύσις).¹

Exegesis and Criticism

I have dwelt on this point, despite the fact that the considerations that it draws upon are of a more general kind than those that I have employed in my analysis up to this point, partly in order to clarify what I believe to be the direct implication of the sentence in Theophrastus, but also in order to establish, from this broader point of view, the more general point that I alluded to earlier: that the sentence from the *De sensibus* quoted at the head of the section before this is intended as criticism, and not as exegesis.

¹ In these sections I have deliberately anticipated a number of points which will be considered more fully in later chapters. For the association of movement with plurality and diversity, see ch. XI § 2, pp.311–15 below. For the dispute over the direction of movement in the atomic system, see below ch. IX § 3, esp. pp.261–2. Other points I have alluded to, and in particular the treatment of Plato and Democritus as 'material monists', the explanation of 'composite weight' in Aristotle's theory, and Aristotle's conception of *prima materia* in relation to weight, will have to await elaboration in my later essays.

In order to avoid undue proliferation I have also deliberately limited my references in support of the various connotations of *physis* and *hyle*: my account is not meant to be controversial. I have also omitted the point that earlier in the fifth century *physis* carried connotations of movement—but not, I think, of movement always and only in a specific direction, as in Aristotle's account of the elements.

(i)

In the *De sensibus* Theophrastus regularly divides his account of each philosopher into a statement of the theories held and a criticism of them. Obviously the attempt to distinguish criticism from exegesis is not uniformly successful. The exegesis is presented with an eye to interests and preoccupations that do not always match those of the original theory. In the course of his criticism Theophrastus does sometimes adduce points of detail that had not found a place in his original statement of the theory.

Nonetheless, the attempted separation of criticism and exegesis is clearly made, and the sentence which I have quoted from later in the *De sensibus* falls clearly within the section of criticism. The preliminary clause, ἀνάγκη, must be critical.

The problem lies not in establishing whether the second and third clauses are critical in intent, but in determining in what way they are intended to be so. In particular, how is it that Theophrastus can introduce 'a single *physis* and a single *hyle*', not as a simple statement of the Atomists' theory, which is the way in which the earlier expression is introduced by Aristotle, but as a 'necessary consequence' of the Atomists' definition of weight, which can be left as a final and sufficient refutation of their theory?

(ii)

The answer, I hope it will now be clear, lies ultimately in the different conceptions of *physis*: the fifth-century view, and the Aristotelean conception. The *physis* of the atoms, thought of as the stuff from which the atoms are made, can act as a premiss to the *physis* of the atoms, and of the elements therefore, thought of as an expression of their movement in a particular direction. The possession of 'a single nature', thought of in the *first* sense, is a direct statement of the atomic theory. The possession of 'a single nature', in the *second* sense, is a consequence of the atomic theory which from the point of view of Aristotle's own conception of the cosmos, shared by Theophrastus, is also a direct refutation of the atomic theory.

Thus when he turns from exegesis to criticism of the atomic theory, Theophrastus first resumes the theory that he had outlined earlier: 'heavy and light are defined by differences of size'. He then draws two related critical conclusions.

1. Since difference of size is the only distinction between heavy and light in the atomic theory, the atoms—which, according to Aristotle, are made from 'a single nature', *physis* in the Democritean sense—and the elements therefore must have the same 'impulse of movement', i.e. they will have movement all in the same direction, with the same speed of movement for equal volumes.

2. From this it follows (ὥστε) that the four simple bodies will have 'a single nature', *physis* in the Aristotelean sense of the word, and a single material principle, *hyle*: i.e. they will fail to exhibit the differences in direction and speed of movement which Aristotle holds to be a primary and an essential expression of the material substance of each of the four cosmic elements.

In the *second* case the conjunction with *hyle* underlines the Aristotelean connotation of *physis*, whereas in Aristotle the comparison with pieces of gold serves to bring out the original fifth-century connotation of *physis*.

(iii)

This, I hope, explains more clearly the fundamental fallacy in Bailey's use of the *De sensibus*. Bailey is mistaken, not only on the particular point, that 'weight' should be given by Theophrastus as 'cause of motion' for the Atomists, but more importantly in his general assumption that at this point in his treatise Theophrastus could still intend to offer an account of the Atomists' original philosophy, instead of his own criticism of it.¹

It is true that there is a certain overlapping between criticism and exegesis, apparent especially in the shift of connotation in the word *physis*, when used by Aristotle, and when used by Theophrastus in conjunction with *hyle*. But the point nonetheless is not

¹ *Greek Atomists* 130–1, cf. pp. 137–42 above.

that, according to Theophrastus, the weight of atoms, in the original Democritean theory, is the cause of their movement in a single direction. The point is that because the weight of the atoms is determined solely by size, therefore Democritus has no means of accounting for the differences in direction and speed of movement which Aristotle and Theophrastus hold to be an obvious and an essential feature of the cosmos.

It is this same confusion of exegesis and criticism in the *De sensibus* that in my second essay I shall argue has led Taylor to read back into Plato's *Timaeus* an essentially Aristotelean conception of weight, and that has blocked the way for a modern understanding of Plato's theory. For again Taylor has taken as a direct expression of Plato's theory the critical constructions that Theophrastus offers us *after* his exegesis of Plato's theory, and that are intended as a *refutation* of it.

Conclusion

(i)

From the fact that the 'nature' of the atoms was homogeneous, Aristotle argues that the atoms can have had movement in only one direction. This Aristotle sees as a denial of his own conviction of the diversity of movements in the cosmos, and in particular as a denial of his own conviction of the movement of earth and fire in opposite directions.

This argument Theophrastus is able to summarise in an expanded version of the formula used to describe the basis of the atomic system, because he adds to the original atomic notion of *physis* the Aristotelean conception of a material principle as defined primarily by movement in a specific direction.

From this point of view, the atoms' and therefore the elements' possession of a single 'nature' becomes in itself a refutation of the atomic philosophy, for once *hyle* is added to *physis* so that 'nature' carries with it the connotation of movement in a specific direction, then the possession of a single 'nature' is at once in direct contradiction with the Aristotelean view of the universe as characterised by a diversity of movements.

(ii)

This leaves us free to summarise the evidence for the atomic theory of weight from Aristotle and from Theophrastus.

In both his initial account of the atomic theory, and in his criticism of it, Theophrastus tells us that Democritus distinguished heavy and light 'by size' or 'by sizes'. In his initial account of the theory, he explains that this means that the weight of each individual atom is dependent upon its size, while 'mixed' or compound bodies are heavier or lighter depending upon the amount of void that they contain.

Precisely these same two features recur in Aristotle's analysis of the atomic theory in the *De caelo*. The larger an atom, the heavier it is, while for compound bodies, at least for compound bodies of the same size, or for compound bodies where the comparison of volume has not been specified, the lighter body is the one which has more void.

In the *De generatione et corruptione*, Aristotle says only that the weight of 'each of the indivisibles'—in effect the same specification as in Theophrastus—is heavier according to its preponderance. In the context, the nature of the preponderance does not need to be, and is not, specified. Nonetheless, from the passage in the *De caelo*, and from the evidence in Theophrastus, we can safely say that Aristotle will have had in mind a preponderance of size.

**PART TWO—
SECONDARY EVIDENCE**

Chapter Five— Simplicius

§ 1— The Weight of Atoms

Theophrastus and Aristotle, we have now seen, agree in attributing weight to the individual atoms. An entry in Aetius explicitly denies that Democritus gave the atoms weight. The same implication has been thought to attach to a second entry in Aetius, and to some remarks in Cicero.¹

The usual reaction to this contradiction, between Aristotle and Theophrastus on the one hand and the *Placita*, or Cicero and the *Placita*, on the other, has been to attempt a compromise. Burnet has been the clearest and the most forceful exponent of this course of action, while Professor Guthrie is the most recent adherent to what is essentially the same view.²

On this interpretation, what Aristotle and Theophrastus say is true only of atoms within a cosmos, or at least within the beginnings of a cosmos, where light and heavy are distinguished as the aggregation of respectively smaller and larger atoms in a vortex. What Aetius reports will be true of atoms which are not caught into a cosmic vortex, and which, in Professor Guthrie's phrase, are 'floating freely in the void'. Epicurus' innovation is then to have added weight, and so downward movement, to atoms existing outside a cosmos.³

¹ Aet. i 12.6, i 3.18. Cicero, *De fato* 20.46. All in DK 68A47.

² Burnet, *EGP* 341–7. Guthrie, *History* ii 400–4, cf. 410. Burnet repeats his interpretation in *Greek philosophy part I Thales to Plato* (London, 1914) 96–101.

³ The evidence for the separation of heavy and light atoms in a vortex is more diffuse than the confident statements in most histories of the subject might lead one to expect.

The process of *ἐκθλίψις* is responsible for the separation of heavy and—by implication—of light atoms, in the atomist cosmogony related at length, but without an author, in Aet. i 4 § 2 (DK 67A24). The same process is specifically attributed to Democritus by Simplicius in two passages which will be quoted and discussed in the course of this chapter, *De caelo* 569.5–9 and 712.27–31 (DK 68A61), pp.154–61 and 157–61 below.

The separation of 'fine' atoms from 'the rest', in a vortex, but without specific mention of light and heavy, is included in the detailed cosmogony attached to

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This interpretation has the advantage of clarity, but it rests, I believe, on a mishandling of the evidence and more generally on a number of questionable presuppositions about the behaviour of the atoms and the nature of ancient conceptions of weight.

However, before turning directly to the evidence from Aetius and from Cicero, I shall consider, in this and in the following two chapters, a number of other passages which bear, or which have been thought to bear, on the problem: from Simplicius, Diogenes and Alexander.

I take first a series of passages from Simplicius, two of which Professor Guthrie introduces in support of his compromise.¹

'De Caelo' 569.5–9

The passage which Professor Guthrie first cites is taken from Simplicius, *De caelo* 569.6–9 (DK 68A61): οὗτοι δοκεῖν τὰ μὲν κοῦφα εἶναι τὰ δὲ βαρέα.

'... they say that all the atoms, being alike in their nature, have heaviness, but in virtue of some bodies being heavier <than others>, the lighter ones are squeezed out by them

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the *Life* of Leucippus by Diogenes, ix 31–2 (DK 67A1), quoted pp.204–5 below. A description of the formation of the earth, in terms of heavy and light, but without specific mention of a *dine*, is attributed to Democritus in an entry in Aetius, iii 13.4 (DK 68A95), quoted below p.374.

The attribution in Simplicius and in Diogenes (and perhaps that in the later of the two entries in Aetius) explains Aristotle's unattributed reference to the distinction of elements by ἐκθλίψις, *De caelo* i 8, 277a33–b2 (not in DK). Simplicius at this point cites only Strato and Epicurus, 267.30. Epicurus is joined with Democritus in the first of the two later passages (569.5–9). In the second passage (712.27–31) Democritus, or rather 'the associates of Democritus', are cited alone.

The fragment of Democritus recorded by Sextus, *Adv. math.* vii 117 (DK 68B164), and frequently quoted in this context, describes only the general movement of like to like, although mention is made at one point of a δῖνος.

¹ *De caelo* 569.5–9 (DK 68A61): *History* ii 403. *Phys.* 1318.30–1319.5 (in part DK 68A58): *History* ii 403 n.3: see below pp.166–73.

The interpretation that I have quoted from Burnet and from Guthrie is adopted by most intervening writers on ancient Atomism, including Léon Robin, *La pensée grecque* (Paris, 1923) 138–9, cf. 141 (although in his later article, quoted p.42 n.2 above, Robin wrote that 'la question reste en somme indécise'), Bailey,

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<i.e. by the heavier ones>: as the <heavier> ones settle below <the lighter ones>, the lighter ones <are thereby made to> travel in an upward direction: through this process these thinkers claim that the appearance arises of some bodies being light and others heavy.'

(i)

Of this passage Professor Guthrie writes that the 'context' in which Simplicius attributes weight to the atoms 'puts it beyond doubt that he is describing the state of things within a cosmic vortex'.¹

But this is only half true. The second part of the sentence does clearly describe the effect of a cosmic vortex. But the first part, equally clearly, does not. For it is plain that atoms do not come to be of a uniform nature only when they are drawn into a vortex: and therefore, on Simplicius' evidence at least, they do not acquire weight only within a vortex, for weight, in Simplicius'

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Greek Atomists 123–48, cf. 82–4, 164, 184, Friedrich R.H. Solmsen, *Aristotle's system of the physical world, a comparison with his predecessors* (New York, 1960) 278, cf. 281 n.23, and Kirk, *Presocratic philosophers* 414–16.

There have of course been exceptions. Löwenheim (1914) adopts an avowedly Newtonian interpretation, which Enriques and Mazzioti (1948) attempt to combine with Burnet's view, while another eccentric version of Burnet's view is given by Bollack (1969): these interpretations I have noted briefly in the Bibliography, where the appropriate references will be found.

I have also noted in the Bibliography a sensible, but rather inconclusive, account of weight by Rivaud (1906) which appeared a year or two before that of Burnet (*EGP* 2nd edn 1908), and a more recent, but again rather inconclusive, move away from Burnet's view by Alfieri (1953), whose conclusion is the closest I know to that which I shall adopt.

The most recent study known to me, since Professor Guthrie's *History*, is by Hans Regnell, *Ancient views on the nature of life, three studies in the philosophies of the Atomists, Plato and Aristotle*, in the series *Library of theoria* 10 (Lund, 1967). Some quite promising pages, 181–204, entitled 'On atomistic theories of motion, with particular regard to the problem of self-mobility', end up nonetheless adopting Burnet's view. Other more recent contributions, by Hahm and Furley (1976), are again noted in the Bibliography; see also p.347 n.3 below.

The historical genesis of Burnet's view, as the outcome of an attempt that was made by a number of scholars in the nineteenth century to escape from Zeller's interpretation of Democritus, is best taken as a separate question, which I shall trace in a later chapter, ch.XIII § 1, pp.347–64 below.

¹ *History* ii 403.

statement, is tied to uniformity of nature: ἔχειν φασί.¹

(ii)

This passage is, in any case, unsuitable for Professor Guthrie's purpose, for it begins by citing both Epicurus and Democritus, 569.5–6 (DK 68A61): ὅσπερ Ἐπίκουρος...

One of the central points of Burnet's original thesis was precisely to distinguish Democritus and Epicurus, and to suppose that only in the earlier system were the atoms without weight before the production of a cosmos, while for Epicurus weight was an invariable characteristic of atomic substance.

Not surprisingly, therefore, Professor Guthrie writes that this passage 'shows a somewhat uncritical juxtaposition of Epicurus and Democritus', since Simplicius here attributes weight equally to the atoms of Epicurus and to those of Democritus.²

But Professor Guthrie's remark is illogical in one or other of two ways.

1. It is inconsistent with Professor Guthrie's earlier remark about the context of the statement limiting its application to the formation of a cosmos. For on Burnet's thesis, which is followed in its essentials by Professor Guthrie, the difference between Democritus and Epicurus lies in their account of the atoms *prior* to the formation of a cosmos. If the present statement referred only to events or to states *within* a cosmos, then there would be no reason to complain that the

¹ The 'cosmic' interpretation of this text began as a justifiable reaction by Brieger, *Urbewegung* 7, against Zeller's attempt to employ the passage as evidence of the atoms' movement in the void, *Die Philosophie der Griechen* Teil i Abteilung 2 6th edn by W. Nestle (Leipzig, 1920) (henceforward ZN) 1086 n.2. It seems to me that the only correct interpretation is to distinguish the two elements in the passage as I have done.

In his later work, 'Urbewegung' 589–90, *cf.* 586, Brieger does come close to making this distinction, since he advances, on his own account, the argument that since the atoms are 'wesensgleich' they must possess weight even prior to the formation of a cosmos. But Brieger does not connect this with his earlier interpretation of this passage in Simplicius, nor does he allow it to alter his general evaluation of Simplicius' evidence: see further pp.351–4 and pp.355–9 below.

² *History* ii 403 n.3.

juxtaposition of Democritus and Epicurus was 'somewhat uncritical'.

2. On the other hand, if it is 'uncritical' to join Epicurus and Democritus, it must be because at least part of the statement attributed to them refers to the nature of the atoms in themselves, and independently of their behaviour within a cosmos. But in that case Professor Guthrie's complaint that the burden of the passage is 'uncritical', and his use of this passage to establish, or to support, his thesis, becomes virtually a *petitio principii*. For Simplicius' juxtaposition of Democritus and Epicurus will be 'uncritical', only if we already suppose that Epicurus was alone in making weight an intrinsic property of the atoms, prior to their use in the formation of a cosmos: and yet that very supposition we are intended to derive, at least in part, from this same passage.

Conclusion

The only conclusion we can properly draw, from this first passage, taken alone, is that, for Simplicius, the atoms of Democritus, no less than the atoms of Epicurus, have weight in virtue of the uniformity of their nature, and independently therefore of their behaviour within a cosmos.

'De Caelo' 712.27–31

Not only is Professor Guthrie's interpretation of this first passage inconsistent in itself: the attempt, or at least the need, in effect to split up the passage, so that the earlier part is true exclusively for Epicurus, while the later part is true for Democritus, or for Democritus and Epicurus, fails when we find later in the *De caelo* that what are virtually the same sentiments are attributed exclusively to Democritus, or in a conventionally equivalent phrase to 'Democritus and his associates', 712.27–31 (DK 68A61): . . . καὶ δεῖ φέρεσθαι πρὸς τὸ μέσον τοῦτο .

'... Aristotle means that Democritus and his associates are wrong in thinking that everything has heaviness, and that it is only in virtue of its having less heaviness that fire travels upwards, doing so because it is pressed out by things that overtake it, the whole process making fire look as though it is light.

'Anyhow (δέ), these are the thinkers who hold that there exists only what is heavy, and that this <namely what is heavy, so far as its natural movement is concerned,> moves always towards the centre.'

(i)

This passage has been badly mauled by Bailey.¹

Bailey claims that in this as in the earlier passage Simplicius' account is restricted to the formation of a cosmos and to the idea of weight as an appearance only.

Thus the final words of the present passage Bailey translates as:

'And to these other things weight only seems to belong, and it seems always to be carried towards the centre.'

This translation Bailey uses to support his conclusion that Simplicius 'regarded "weight"' in the atomic theory 'not only as a derivative property of the atoms but even in some sense as illusory'.

But Bailey's translation betrays an elementary misunderstanding of the Greek: a confusion of

καὶ οὐχ ὥσπερ οἶονταί τινες πάντ' ἔχειν βάρος· βαρὺ μὲν γὰρ δοκεῖ τισὶν εἶναι καὶ ἑτέροις. The point is not that 'heaviness only appears to belong to some things', but that 'Democritus reckons that what is heavy alone exists'.

(ii)

Indeed, these lines must be used to clarify the intention of the

¹ *Greek Atomists* 131–2 Bailey's references (p.131 n.5) have somehow gone awry, but it is clear that he intends to refer to this passage.

earlier passage, 569.8–9: οὕτω λέγουσιν οὗτοι δοκεῖν τὰ μὲν κοῦφα εἶναι τὰ δὲ βαρέα.

Following the same line of thought that Bailey was later to pursue, Brieger wrote of this passage: 'deutet das δοκεῖν darauf hin, dass es sich um den Bereich der Erscheinung handelt'.¹

But a distinction is needed.

1. In the present passage, the point is that the Atomists do reckon that everything has heaviness. The point is that what is heavy *alone* exists: and that lightness only 'appears' to be.
2. In the earlier passage, therefore, what belongs to the world of appearance—even if we are willing to allow for a moment the propriety of such a potentially emotive paraphrase—is not that the atoms have heaviness. It is the conjunction of heavy and light that only 'appears' to be.

The difference between the two passages, therefore, and it is a difference of expression only and not of substance, is that what 'appears' in the later passage is lightness, while what 'appears' in the earlier passage is the conjunction of heavy and light.

The point to appreciate is that in neither case is the atoms' having weight intended, by Simplicius at least, to be inconsistent with, or even separable from, the notion that light, or heavy and light, 'appear' in the formation of the cosmos.

In fact the opposite is the case. Simplicius' point is that heaviness alone is reckoned as an intrinsic property of the atoms, and that because of the phenomenon known to Aristotle and the doxographical tradition as ἐκθλιψις some of the atoms, or their products, *appear* to rise and so to be light, and therefore what is in truth only a difference between heavy and light in the sense of more and less heavy appears as a distinction between heavy and light in the Aristotelean sense of movement in opposite directions.²

(iii)

There remains the question of a difference of subject between the earlier and the later passage. Bailey appears to think that in

¹ *Urbewegung* 7.

² For references to ἐκθλιψις see p. 153 n.3 above.

the first passage (*De caelo* 569.5–9) Simplicius speaks only of atoms, and in the later passage (*De caelo* 712.27–31) only of compound bodies.¹ But, as Brieger had noted, the antithesis between τῶ δ' εἶναι τινα βαρύτερα, in the earlier passage, could mean that compound bodies are intended in the earlier passage as in the later.²

On the other hand, Brieger's refinement may not be necessary. Epicurus himself, in the *Letter to Herodotus*, slips from the feminine atoms (τὰ βαρέα), evidently with no real change in the reference of the subject.³ Simplicius could have done the same.

The distinction, between atoms and compound bodies, does appear in the passage I quote at the beginning of the section following this (*De caelo* 269.4–14). But if the interpretation that I offer of the present two passages is correct, it makes little difference in fact whether the 'appearance' of heavy and light attaches to single atoms or to groups of like atoms.

In either passage, the point to appreciate is that the appearance of 'lightness' or of the conjunction of 'heavy and light' attaches to the atoms or their products, whereas in truth 'all things' (cf. τὰς ἀτόμους πάσας, 569.6), have only heaviness. In neither passage is there any indication of an intention to limit the possession of heaviness to bodies that are formed from the atoms, to the exclusion of the atoms themselves.⁴

Conclusion

It is impossible, therefore, from these two passages at least, to

¹ *Greek Atomists* 131–2.

² *Urbewegung* 7, 'Urbewegung' 589.

³ *Ep. ad Her.* 61, quoted pp. 184–5 below.

⁴ It is interesting to note that in his commentary on the *Letter to Herodotus* Bailey claims, *Epicurus* 217, that there is a change of subject, from atoms to 'bodies in general'. This is curiously at variance with his assumption, *Greek Atomists* 131–2, that the identical terminology in the earlier passage of Simplicius (569.5–9) refers exclusively to the atoms. I doubt myself that there is a real difference of subject in either passage. Certainly in Epicurus (*Ep. ad Her.* 61) the argument requires that the latter subject (τὰς ἀτόμους).

use Simplicius' authority to drive a wedge between Epicurus and Democritus on the question of atomic weight.

1. In the later passage, Simplicius attributes to Democritus on his own the view that heaviness alone belongs to the atoms or their products, and that it is only their behaviour within a cosmos which gives the appearance of there being light things as well.

2. Virtually the same two ideas are attributed jointly to Democritus and Epicurus in the earlier passage, where the fact that the atoms' weight is tied to their being *δμοφυεῖς* makes it incontestably clear, it seems to me, that weight is intended, by Simplicius at least, to be an intrinsic character of the atoms, and not tied exclusively to their behaviour within a cosmos.

So far therefore, Simplicius affords no evidence for distinguishing Epicurean atoms which have weight from Democritus' supposedly weightless atoms, nor any support for the idea that weightless atoms can give the appearance of weight when they are caught into the formation of a cosmos.

§ 2—

Weight and Movement: 'De Caelo'

A third passage from the *De caelo* confirms this conclusion, while raising a fresh point of interest. Simplicius writes, 269.4–14 (not in DK):

βάρους τοῖς συνθέτοις αἰτίας, ὥσπερ κουφότητος τὸ κενόν

'The student should be aware that Strato and Epicurus were not the only ones to claim that all bodies are heavy, and that their <only> natural movement is movement downwards <so that> all bodies are moving against their nature when they move upwards: Plato too was aware of this <opinion?> and he argues against it . . .'

There follows an explanation and a quotation of a passage from the *Timaeus*, 62C5-8, where Plato denies that the universe can be divided 'by nature' into opposite places that are 'up' and 'down', and where he denies in particular that bodies which move 'upwards' do so 'unwillingly'. Simplicius continues:

'<This text is explained by the presence of> those who believed in atoms <and who> claimed that as the atoms were full <or dense> they were heavy themselves, and the causes of heaviness in compound bodies, just as <in compound bodies the cause> of lightness is the void.'¹

The Question of Weight

The Atomists whom Simplicius writes of in the last sentence I have quoted are clearly intended to be Atomists who lived before Plato, and are distinguished therefore from Epicurus. (My paraphrase makes explicit the connection of thought that I believe is intended in the Greek.)

The atoms of Democritus therefore, or of Democritus and Leucippus, are said to be causes of heaviness in other things, in virtue of being themselves heavy. This is clearly the intention of: βαρείας ἔλεγον αὐτάς (sc. τὰς ἀτόμους) καὶ βάρους τοῖς συνθέ-τοις αἰτίας.

At the same time, the atoms are said to be themselves heavy in virtue of their being solid: ναστάς οὖσας (sc. τὰς ἀτόμους) βαρείας ἔλεγον αὐτάς.

This sentiment approximates to Simplicius' later statement that the atoms are heavy in virtue of their uniformity of nature, 569.6: τὰς ἀτόμους πάσας ὁμοφυεῖς οὖσας βάρος ἔχειν φασί.

In either case, the implication is that the weight of atoms, in being tied to their uniformity of nature and to their solidity or density, is an intrinsic character of atomic substance, and is not dependent upon the position of the atoms within a cosmos.

So far, therefore, this passage conforms to, and in part con-

¹ Simplicius' simple division between void as cause of lightness and atoms as cause of heaviness has already been met with, p.96 above, and is taken account of in my third essay. I shall consider in my second essay whether, or how far, Plato's passage relates to the Atomists; in what follows I am concerned only with the connection of thought in Simplicius.

firms, the two points which were established by my earlier analysis.

1. If we correlate the production of compound bodies with the action of a vortex within a cosmos, or within the beginnings of a cosmos, then here, as in the two passages noted earlier, the distinction of heavy and light bodies is dependent upon the atoms' being themselves heavy: there is no question of supposedly weightless atoms producing a distinction between heavy and light.

2. According to Simplicius, the atoms are heavy in their own right, in so far as their weight is tied to their density and to the uniformity of their nature.

The Question of Movement

(i)

In this study, I adopt the view which since Brieger's and Liepmann's critique of Zeller has been almost universally endorsed, and which is shared by Burnet and by Guthrie, that in Epicurus' system alone the atoms 'fall' downwards in the precosmic void, whereas in the earlier system the precosmic atoms moved at random in all directions.¹

¹ The contributions by Brieger and Liepmann have already been cited: see in the Bibliography Brieger (1884 and 1904) and Liepmann (1885). This view is adopted by Burnet, *EGP* 344–6, and by Guthrie, *History* ii 400–4.

Zeller's view is finally re-stated in ZN 1076–99. Among more recent writers, G. Capone-Braga is the only person I remember coming across who deliberately keeps to Zeller's interpretation, 'Aristotele, Epicuro e Diogene di Enoanda', *Atene e Roma* serie 3 anno 8 (1940) 44–5. Cf. also Furley in the Bibliography.

The main argument turns on whether to accept the assumption of downward movement made by Aristotle in several criticisms of Democritus, or whether to follow the implication of Aristotle's other repeated criticism, that the Atomists failed to specify the nature or the cause of the movement of atoms in the void: cf. pp.236–8 and 261–4 below.

A subsidiary argument turns on the implication of the atoms' 'whirling in the void' (ἀθροισθέντα δίνην ἀπεργάζεσθαι μίαν, Diog. Laert. ix 31 = DK 67A1, quoted pp.204–5 below). Zeller, ZN 1082–4 and 1096, takes the two passages as alike describing an early stage in the formation of the cosmos; but the two contexts are not identical, and it is at least as natural to understand the former passage as a generalised description of the behaviour of the atoms in a precosmic void.

The question of movement provides a parallel test of Simplicius' reliability on the question of weight.

Simplicius attributes weight equally to Epicurus' atoms and to the atoms of Democritus. Does Simplicius attribute downward movement to Epicurus and to Democritus indiscriminately, or to Epicurus alone?

1. If Simplicius can be shown to have confused Democritus and Epicurus on the question of movement, then it will be the more pertinent to argue that he may equally have failed to distinguish the atoms of Epicurus, which have weight, from the supposedly weightless atoms of Democritus.
2. On the other hand, if Simplicius can be shown not to have confused Epicurus and Democritus on the question of movement, then the inference will be that Simplicius' attribution of weight to Democritus' atoms is the less likely to result from confusion of Democritus with Epicurus.

(ii)

In the passage I have quoted, Epicurus and Strato, like Democritus, are said to have believed, in effect, that heaviness 'alone' exists.

At the same time, Epicurus and Strato, in Simplicius' account, identify weight with 'natural movement in a downward direction': πάντα ἔλεγον εἶναι τὰ σώματα βαρέα καὶ φύσει ... ἐπὶ τὸ κάτω φερόμενα .

The earlier Atomists at first appear to be introduced as having the same set of beliefs: φύσει μὲν ... παρὰ φύσιν δέ ... ἀλλὰ καὶ ὁ Πλάτων οἶδε κ.τ.λ.

Certainly, in so far as the earlier Atomists are introduced to exemplify the passage quoted from the *Timaeus*, the assumption must be that within a cosmos the atoms, or the products of the atoms, move towards the centre. This indeed is what the atoms, or their products, are said to do in the passage which I quoted from towards the end of the *De caelo*, 712.30–1: τούτοις δὲ τὸ βαρὺ μόνον εἶναι δοκεῖ καὶ αἰεὶ φέρεσθαι πρὸς τὸ μέσον τοῦτο .

However, Simplicius does not say that outside a cosmos Democritus' atoms move downwards 'by nature', nor does he ascribe to the earlier Atomists the distinction between natural and unnatu-

ral movement which he does ascribe to Strato and to Epicurus.

(iii)

The omission is significant. For elsewhere Simplicius in fact denies that Democritus' atoms have natural movement.

1. The atoms of Democritus are in constant movement, but it is movement which is determined 'by force', *De caelo* 583.20–2 (DK 67A16): ἀπείρῳ κενῷ βίῳ. 'The associates of Leucippus and of Democritus claimed that what they supposed to be the primal particles, namely the atoms, were in continual movement, in the endless void, as the result of force.'
2. The atoms of Democritus are moved by force of impact, and they have no natural movement, *Phys.* 42.10–11 (DK 68A47): Δημόκριτος φύσει ἀκίνητα λέγων τὰ ἄτομα πληγῇ κινεῖσθαι φησιν. 'Democritus claims that the atoms have no natural movement and he claims therefore that they are moved by the force of impact.'¹

From these two passages it follows that while Simplicius envisages Democritus' atoms, or the products of the atoms, as drawn towards the centre of the cosmos, and thereby as giving rise to the ἐκθλιψις of smaller atoms, or groups of atoms, nonetheless he does not envisage the atoms themselves as moving downwards in the void.

For if they did, they would have 'natural movement', like the atoms of Epicurus, and this Simplicius expressly denies.

Conclusion

Thus there are three important conclusions to be drawn from this neglected passage, and from the pair of passages which I considered in the section preceding this.

¹ On the meaning of the phrase φύσει ἀκίνητα see below pp.224–6.

1. According to Simplicius, Democritus' atoms are both heavy in themselves and cause of heaviness in the substances that are formed from them.
2. They are heavy in virtue of their density, and in virtue of the uniformity of their nature, and independently therefore of their position or behaviour within a cosmos.
3. When, in this most recent passage, Simplicius writes of Epicurus' atoms as 'moving downwards by nature', passages elsewhere show that he thereby in effect distinguishes the atoms of Epicurus from those of Democritus at the one point where we believe it to have been necessary: the association of weight and of movement downwards.

§ 3—

Weight and Movement: 'Physics'

A passage in the *Physics* raises more directly the question of the association of weight with movement. Simplicius writes of Democritus' atoms as moving 'because of', or perhaps more loosely 'in accordance with', their weight, 1318.30–1319.5 (in part DK 68A58): *καὶ ἀποκρινομένων τῶν πρώτων σωμάτων φασίν*.

'So much for the ideas of those who set up an efficient cause in the forefront of <their theory of> the genesis of things existent <and who do so in such a way as to acknowledge the primacy of local movement>.

'Others do not think to establish an efficient cause, but in their theory of movement—I am thinking of the theory of Democritus and his associates, where void has a determining

role—they still think of the movement of "physis" as a local movement.

"Physis" in this theory means the physical bodies which are primary and indivisible. These bodies Democritus and his associates called "physis", and they claimed that these bodies have a local moment, whereby in response to (**κατά**) the heaviness that is in them they move through the void which gives way before them and offers no resistance <to their passage>, as, in their own expression, the primary particles "dart about hither and thither".

'Indeed not only do these theorists offer this <local> movement as the primary movement: it is the only movement that they will allow to the elements <of their system, the atoms>; <all> other movements, in their theory, belong <not to the atoms or elements but> to bodies that are formed from the <atoms or> elements. In other words, increase and decay, qualitative change, coming into being and passing away, <are all movements that> they claim as the consequence of the conjunction and separation of the primal bodies <the atoms>.'

‘περιπαλάισσθαι’

(i)

Professor Sambursky has acutely observed that when Simplicius describes the void through which the atoms move as 'yielding and unresistant'

τὸ μὲν οὖν 'ἐκούσιον', τὸ εἶκον καὶ μὴ ἀντιτυποῦν...¹

This might be merely coincidental. But I think that Professor Sambursky is probably right to take the expression in Simplicius as an indication that, in the context of the passage as a whole, Plato's contrast of what is voluntary and what is necessary is

¹ S. Sambursky, 'A Democritean metaphor in Plato's *Kratylos*', *Phronesis* 4 (1959) 1–4. The 'yielding' nature of the void (**ὑπέεικειν**), as cause or condition of movement, is specified as a feature of the theory which Aristotle attacks in book four of the *Physics*, see iv 8, 215a22–3, cf. 214b16–17 and 216a21–6.

intended, at least in part, as a covert critique of the atomic theory.

Taken in this way, the two passages complement one another.

1. The attribution in Simplicius points to the provenance of the theories which Plato employs as the basis for his etymology, and for his criticism.
2. The occurrence of the expression in Plato adds authority to Simplicius' account of early Atomism, and in particular it reinforces his claim, in the sentence immediately following, to reproduce an original expression from the atomist theory: 'περιπαλαίσεσθαι' γὰρ ἔλεγον αὐτά (sc. τὰ πρῶτα καὶ ἄτομα σώματα) ¹

¹ The qualification which I would add to Sambursky's article is that he appears to think of the *metaphor* as originating with Democritus: '... it stands to reason that Simplicius quotes literally either from Democritus' writings or from some work using a metaphor which goes back to Democritus' (p.1).

Sambursky has been carried away by the context of the expression in Plato. There is nothing necessarily metaphorical in speaking of the void as 'yielding' or as 'unresistant'. ἐκούσιον is applied to matter, or void, *or* when 'yielding' and 'unresistant' are transferred from a technical, or semi-technical, description of matter or void to a description of persons or their actions. Rather interestingly, the *first* transition, in its negative form, occurs in the passage of the *Timaeus* which Simplicius alludes to in connection with Democritus (62C7, cf. Simpl. *De caelo* 269.4–14, quoted at the beginning of the preceding section), where Plato attacks the idea that any body which moves upwards does so 'unwillingly'; even so, instead of being in any way deliberately metaphorical, this usage perhaps rather indicates the animism latent in the ideas which Plato is attacking. There is no indication that the *second* transference, which is the one that Professor Sambursky is more interested in, has occurred outside Plato.

Indeed the point of Plato's reminiscence in the *Cratylus* would seem to me to lie principally in Plato's transposition of terms that in Democritus had been used largely or exclusively in a material sense, to the context of ignorance and error that we find in the *Cratylus* or—if we follow Sambursky's argument—to the context of reason, persuasion and necessity that we find in the *Timaeus*.

If there were to be a non-material connotation in the Atomists' original use of the expression, then I would prefer to find it, not in the moralising context which Plato gives to the term, but in association with the vocabulary in the fragment which Simplicius quotes from Aristotle's treatise on Democritus, where the atoms are 'at war' ἐἴκειν see LSJ s.v. For the collocation of the two texts in Simplicius, the present passage from the *Physics* and Simplicius' quotation of Aristotle's fragment on Democritus, see below ch.XI § 1, pp.303–10).

(ii)

I turn therefore to the reading περιπαλαίσεσθαι.

Diels' emendation to περιπλέκεσθαι.¹

But while McDiarmid may be right in casting doubt on some other instances where, with little encouragement from the manuscripts, περιτάλαξις have perhaps too zealously been restored to texts touching upon the atomic theory, yet in this case McDiarmid's attempt to follow the principle of the *lectio facilior* leads to a reading which has little resemblance to what is offered by the manuscripts.

More particularly, McDiarmid is wrong in writing that 'the context of Simplicius offers no definite clue to the correct reading'.²

For what is at least clear in this context is that while Simplicius' point is that the Atomists reduce every kind of 'movement', in Aristotle's sense of the term, exclusively to local movement, at the same time Simplicius distinguishes in effect two kinds of local movement.

1. There is first the simple movement of atoms in space.
2. There is then their conjunction with, and disjunction from, each other: their 'mixture', so to speak, and their separation.

Thus the point to be appreciated is that in this context local movement, ἀυξάνεσθαι ... καὶ φθίνειν καὶ ἀλλοιοῦσθαι καὶ γίνεσθαι καὶ φθείρεσθαι.

It is therefore inappropriate for περιπαλαίσεσθαι to be replaced

¹ H. Diels, edn of Simplicius' *Physics* (Berolini, 1895) 1319.1, and 'Aristotelica', *Hermes* 40 (1905) 306–8. J.B. McDiarmid, 'Phantoms in Democritean terminology: περιπαλάσσεσθαι', *Hermes* 86 (1958) 291–8.

² 'Phantoms' 295.

by προσκρινομένων .

Indeed, it is impossible for Simplicius to write of only *one* of the two contrasting forms of local movement that it is not only the primary but the *only* kind of movement which is attributed to the atoms, as he will have to do if we accept McDiarmid's emendation, 1319.1–3: οὗτοι κίνησιν τοῖς στοιχείοις ἀποδιδόασιν .

On the contrary, the formula, 'not only the first but the only movement', requires that whatever replaces κατὰ τόπον κινεῖσθαι .

This would be achieved by περιπάλλεσθαι , which Diels also suggested.

But the simplest, and the smallest, alteration of the manuscripts will be to adopt περιπαλάσσεσθαι , however much, or however little, support it may gain from passages elsewhere.¹

(iii)

What then is the meaning of περιπαλάσσεσθαι ?

Hesychius records περιπαλαχ-θῆναι . This cannot be the meaning here, although it is perhaps intelligible as explaining one *result* of local movement.

The uncompounded verb, πάλλω is used more generally, but often of the kind of fast and even violent movement that I shall argue later is appropriate to the movement of atoms in the void.³

The prefix - will add the sense of 'round and round' or 'round and about' or 'hither and thither'.⁴ The meaning will be

¹ Conscious, as ever, of the dangers of proliferation in this kind of study, I hope that the reader will not feel cheated if I use this formula to cut myself off from detailed examination of the other passages which McDiarmid quotes, some of which, I do in fact believe, support the use of the term.

² LSJ s.v.

³ LSJ s.v. See pp.179–81 below.

⁴ See LSJ s.vv. περιφέρω .

therefore that the atoms are 'scattered' or 'tossed about', or that they 'dart' or 'shoot' or 'leap around': precisely the meaning, in fact, which is conveyed by Lucretius' repeated use of the term *iactari* in his account of the movement of atoms in the second book of the *De rerum natura*.¹

Movement 'κατὰ τὴν ... βαρύτητα'

I turn therefore to the use of this passage as evidence for the question of weight, with particular reference to the relation of weight and movement.

As I have already noted, I adopt in this study the view which since Brieger's and Liepmann's critique of Zeller has been almost universally endorsed, and which is shared by Burnet and by Guthrie, that in Epicurus' system alone the atoms 'fall' downwards in the precosmic void, whereas in the earlier system the precosmic atoms moved at random in all directions.

It is interesting to observe the use which representatives of these two interpretations make of the present passage.

1. Zeller uses it as an important piece of evidence that for Democritus, as for Epicurus, the atoms are moved by weight and so must 'fall' in the void.²
2. Professor Guthrie writes that in this passage Simplicius 'shows a similar confusion' to that in the passage which he quotes from the *De caelo*, in that 'the atoms are said to move through the unresisting void by reason of their weight (as they certainly did for Epicurus), but this motion is then

¹ Lucretius, ii 89, 122, 548.

Since Aristotle's reading at *De caelo* iii 4, 303a8, is explained by Simplicius, 609.24–5, as meaning ἐπαλλάττει is the reading to be preferred, both since it is the only reading to occur at once in the manuscripts of Aristotle and in those of Simplicius, and because it makes excellent sense.

J. Bollack also defends Diels' conjecture against McDiarmid, with the sense of 'l'éclaboussement', 'Deux figures principales de l'atomisme d'après Aristote: l'entrecroisement des atomes et la sphère du feu', *Symposium Aristotelicum* 4 (Heidelberg, 1969) 38–42, the same translation as in Robin, *La pensée grecque* 140 ('éclaboussement en tous sens').

² ZN 1085 n.3.

described by a word which cannot apply to a consistently downward fall'.¹

Thus in finding once again 'confusion' with Epicurus, Professor Guthrie, while avoiding Zeller's conclusion, in effect perpetuates his assumption that movement 'by reason of weight' should be expressed by movement downwards.

If we do *not* make this assumption, then the lesson of this passage will be precisely the *opposite* of the lesson which Professor Guthrie seeks to draw from it, and the *same* as the lesson of the passage which I last quoted from the *De caelo*.

For if movement 'according to weight' does not entail movement downwards, then the nature of the movement attributed here to Democritus will be determined by the meaning of περιπα- λάσσεσθαι or its variant.

If this term 'cannot apply to a consistent downward fall', then it will serve precisely to distinguish the movement of Democritus' atoms from the downward movement which was the exclusive characteristic of Epicurus' system.

Not only, in that case, will Simplicius not have confused Democritus and Epicurus. At the one point where we believe it to have been necessary, he will again in effect have distinguished the two.

Conclusion

Simplicius' evidence has been adduced in support of what I have called the current compromise: namely the view that the atoms of Democritus have weight only when they are caught into a cosmic vortex, and that evidence in Aetius and Cicero, which denies that the atoms have weight, is true of atoms which are 'floating freely in the void'.

But the truth is that a study of four leading passages in Simplicius, once a number of obvious errors of mistranslation and of false inference have been cleared away, leads to the opposite con-

¹ History ii 403 n.3. Guthrie is following a long tradition here: Papencordt, *Atomicorum doctrina* 35 n.2, Mullach, *Democriti fragmenta* 384, Brieger, *Urbewegung* 7–8, Vittorio E. Alfieri, *Gli Atomisti, frammenti e testimonianze, traduzione e note di V.E.A.* (Bari, 1936) 100 n.232, Kirk, *Presocratic philosophers* 417 n.1. For Guthrie's use of *De caelo* 569.5–9 see pp.154–7 above.

clusion: that the atoms of Democritus do have weight, even outside a cosmos.

1. In a passage in the *De caelo*, Simplicius writes that the atoms have weight in virtue of 'the uniformity of their nature', and so, one would suppose, independently of their relation to a cosmos. It is true, this opinion is attributed both to Democritus and to Epicurus: but in two other passages virtually the same sentiments are attributed to Democritus on his own.

2. At the same time, in the *De caelo*, although Simplicius attributes 'natural' movement downwards to the atoms of Epicurus, he regards the atoms of Democritus as moving 'by force'. The implication is made explicit in a passage in the *Physics*: the atoms of Democritus are there spoken of as 'darting hither and thither' in the void 'because of' or 'in accordance with' their weight.

This will betray 'confusion' only if we suppose that movement 'according to weight' is necessarily movement downwards. If we do not make that assumption, then the message from Simplicius is clear: the atoms of Democritus do have weight, even in the void, but they do not therefore move downwards in the void, as the atoms of Epicurus do.

Chapter Six— Simplicius and the Current Compromise

§ 1—

The Nature of Weight: Weight Expressed As Movement Downwards

The question which we are led to therefore, from our study of Simplicius, is whether, or for whom, movement by weight entails movement downwards.

This question lies at the heart of our enquiry, for in supposing that if the atoms have weight they must therefore fall, and in finding thereby a confusion between Epicurus and Democritus in the passage I have quoted from Simplicius' *Physics*, Professor Guthrie reflects the influence on his mind of a presupposition which has lain at the root of modern interpretations of Democritus' theory of weight.

This presupposition is expressed with equal clarity and with equal confidence by both Zeller and Burnet.

'Unter der Schwere hat . . . niemand im Altertum etwas anderes verstanden als diejenige Eigenschaft der Körper, vermögen deren sie sich nach unten bewegen, wenn ihnen dies nicht durch ein äusseres Hindernis verwehrt wird.'¹

'Zeller rightly argues . . . that, if the atoms have weight, they must fall.'²

What should at once arouse our suspicion, even apart from the lack of any evidence being offered, is that the adoption of this principle leads to directly opposite conclusions for Zeller and for Burnet.

1. Zeller argues that the precosmic atoms of Democritus do have weight, and that they must therefore fall.

¹ ZN 1084.

² *EGP* 345 n.1. I can see only fresh confusion in the fact that earlier Burnet purports to contradict Zeller's definition, *EGP* 343 n.3, quoted by Nestle, ZN 1084 n.3.

2. Recognising, rightly, with Brieger and with Liepmann, that Zeller's conclusion is contrary to the evidence, Burnet concludes that since the atoms do not fall they can have no weight.

This conflict needs only, I think, to be stated clearly for it to be at once apparent that instead of shooting off in opposite directions from a common principle, it is to this principle itself that critical attention should be directed. For it is only the supposedly inviolable force of the entailment between weight and movement that leads to the supposition *either* that the atoms have weight and therefore move downwards *or* that the atoms do not fall and are therefore weightless.

The radical alternative will be to abandon the entailment of weight and movement. This will at once enable us to embrace the only two conclusions for which there is sufficient, and satisfactory, evidence.

1. The precosmic atoms of Democritus do have weight.
2. They do not move only downwards.

'Weight' in Burnet

The place which weight and movement in fact occupied in the conceptual fabric of fifth-century philosophy I shall attempt to outline in a later, more general chapter.¹

For the moment, it will perhaps be sufficient for my argument if, in order to point to the weakness of the notion that weight, for the Presocratics, necessarily entails, and is defined by, movement in a specific direction, I do no more than point out the steps by which Burnet argues in its support.

With even more than his accustomed *panache*, Burnet sets out to portray early notions of weight.

'It is clear that lightness and weight would be among the very first properties of body to be distinctly recognised as such. The necessity of lifting burdens must very soon have led men to distinguish them, though no doubt in a crude

¹ Ch.XIII § 2, pp.364–83 below.

form. Both weight and lightness would be thought of as *things* that were *in* bodies. Now it is a remarkable feature of early Greek philosophy that from the first it was able to shake itself free from this idea. Weight is never called a "thing" as, for instance, warm and cold are; and, so far as we can see, not one of the thinkers we have studied hitherto thought it necessary to give any explanation of it at all . . . !

The crunch comes in the next seven words:

. . . *or even to say anything about it* (my italics).

Burnet's whole construction suddenly collapses into an argument *ex silentio*.¹

But if the Presocratics say nothing about weight, then we cannot possibly tell whether heavy and light are, or are not, distinguished by them from such common characters as warm and cold.

What is more, from Burnet's own admission, we should rather conclude that they were not so distinguished. For if it would be a 'remarkable feature' of primitive thinking for the status of heavy and light to be distinguished from the status of such opposites as warm and cold, then in the absence of evidence either way, it would be more sober and more honest, if we were to come to a conclusion at all, to conclude that such a development had not taken place, rather than that it had.

¹ *EGP* 342. In support of the sentence which I have italicised Burnet writes, *EGP* 342 n.2: 'In Aet. i 12, where the *placita* regarding the heavy and light are given, no philosopher earlier than Plato is referred to'. This is in fact the section in which it is stated of Democritus that his atoms 'have no weight' (see ch. VIII § 1, pp.223–9 below). This may be a negative *placitum*, but it is a *placitum* nonetheless.

Solmsen repeats without correction Burnet's remark, *Aristotle's system* 277 n.8: Burnet 'attaches importance to the fact that the *Placita* (see, e.g., *Doxographi* 310) report no doctrines about heavy and light earlier than Plato's'. The chapter which begins on the page quoted (*Dox.* 310 = Aet. i 12) is again precisely the chapter which contains (*Dox.* 311.18–22 = Aet. i 12.6) the entry where 'Democritus says that the first bodies . . . have no weight'. It is quite extraordinary that both Solmsen and Burnet should in this way deny the existence of the very evidence on which they depend for their belief that outside a cosmos Democritus' atoms 'have no weight' (*cf.* p. 154 n.1 above).

But worse is to come. When Burnet proceeds to outline Plato's theory of weight, where weight is associated with, and in part explained by, movement in a specific direction, he concludes precisely: 'Here Plato is really giving the view taken more or less consciously by his predecessors'. Later on the same page Burnet adds that Plato's view, in its immediate effects, is substantially the same as that adopted by Aristotle.¹ Thus while setting out deliberately to isolate early notions of weight, Burnet in effect saddles the Presocratics with precisely that entailment of weight and movement which was the essential characteristic of Platonic and Aristotelean philosophy.²

'Floating Atoms'

Hardly less chimerical is the picture which Professor Guthrie provides of Democritus' precosmic atoms 'floating freely in the void'.³

If this picture is not simply the product of an imagination coloured by modern notions of space, then it has perhaps taken its rise from the words of Aristotle which Burnet paraphrases, in the context of his discussion of weight, as 'the comparison of the motion of the atoms of the soul to that of the motes in a sunbeam coming through a window'. It is possible, Burnet adds, that this 'is really intended as an illustration of the original motion of the atoms still surviving in the soul'.⁴

¹EGP 343–4.

²Burnet's observations have clearly influenced Cornford's remarks on the same subject, as is noted by Solmsen: see Francis M. Cornford, *The laws of motion in ancient thought* (Cambridge, 1931) esp. 37–9, cf. Solmsen, *Aristotle's system* 277 n.8. In particular, Cornford advances the same close association of Aristotelean, Platonic and Presocratic ideas that is to be found in Burnet, though he does so with perhaps a little more justification than Burnet, since Cornford's purpose is not so much to isolate earlier ideas of weight as to present certain radical contrasts between ancient and modern ways of thinking. Nonetheless I suspect it may be Cornford's tacit endorsement of Burnet's ideas at this point which has encouraged later Cambridge scholars, notably Guthrie and Kirk, to accept Burnet's ideas on the subject, and especially his interpretation of Democritus, with such lack of critical scruple (cf. p.154 n.1 above; see also pp.347–8 and 363–4 below).

³*History* ii 403.

⁴EGP 345–6; Burnet's suggestion is also picked up by Bailey, *Greek Atomists* 133, and by Kirk, *Presocratic philosophers* 417. Aristotle, *De anima* i 2, 403b31–

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However, considerable caution is needed in handling Aristotle's comparison.

(i)

In the first place, the application of the image of the sunbeam to atoms other than those of the soul does not occur before Lucretius.¹ It may well be peculiar to Epicureanism.

1. The *clinamen* of the precosmic atoms, in the later theory, is ascribed to atoms of the soul, to provide for *libera . . . fatis auulsa uoluntas*.²

2. It is very possible that a similar association of ideas has led, but again only in the later theory, to the image of the sunbeam travelling in the opposite direction, so to speak: from illustrating the movement of atoms constituting soul, to illustrating the movement of atoms in general.

(ii)

Even if we do consider the latter comparison, it is essential, as in the use of all such images, to pick out carefully the *tertium comparationis*.

In the psychological application of the image, the point of comparison was perhaps the notion of continuous and spontaneous movement. At least, this was the sense in which the idea was originally used, Aristotle tells us, by certain Pythagoreans, for whom the motes were in fact particles of soul, and not merely, as for Democritus, an image of the atoms that constitute soul.³

In Lucretius, the cosmic application of the image serves two purposes.

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404a20 (DK 67A28 + 58B40). There is a recent study of the comparison of the atoms with motes in a sunbeam, containing a useful collection of passages, and including a fragment, hitherto unknown, of an Arabic work, by G. Strohmaier, 'Demokrit über die Sonnenstäubchen', *Philologus* 112 (1968) 1–19.

¹Lucretius ii 112–41.

²Lucretius ii 256–7.

³Arist. *De anima* i 2, 404a16–20 (DK 58B40). I add 'spontaneous' to distinguish the Pythagoreans who treated soul as the motes themselves from those who treated soul as τὸ ταῦτα κινεῖν. In writing that the idea was 'originally'

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1. It is first used to illustrate the collision and recoil of atoms.
2. It is then used to illustrate how these same turbulent movements secretly underlie, and are contained within, the objects apparent to sense, which by a pretty transference of the original image Lucretius describes as *illa . . . in solis quae lumine cernere quimus*.

The *first* application of the image will be that which corresponds to Burnet's suggestion of the image as illustrating 'the original motion of the atoms'.

But in that case the lesson, the *tertium comparationis* of the image, at least as it appears in Lucretius, is not that of atoms '*floating freely* in the void' (my italics). It is that of the collision and entanglement (*concilia*) and the separation and recoil (*discidia*) of atoms.¹

Thus even in the later employment of the image there is no deliberate notion of atoms 'floating freely in the void'.

The Clash of Atoms

But perhaps the notion of atoms 'floating freely in the void' is not intended to be dependent upon the image of motes in a sunbeam.

If not, it has no other authority. For the few potentially authentic allusions that survive to the nature of the precosmic movement of the atoms suggest a very different picture.

1. **Στασιάζειν** in Aristotle's account, recorded by Simplicius, has already a rather different connotation from the peaceful 'floating' of atoms.²
2. **Ἐπίπτειν**, also in Aristotle, can be used in a peaceful

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used by Pythagoreans, I am simply assuming that these Pythagoreans were prior to Democritus: the theory has an archaic ring.

Rather interestingly, the analogy recurs, in a different connection, in Alexander, *Met.* 631.8–11, cf. p.276 n.1 below. For Simplicius' criticism of Aristotle's treatment of the Pythagoreans in this passage see below pp.279–81.

¹ See especially Lucretius ii 114–24.

² Arist. *ap. Simplicius. De caelo* 295.9–13 (fr. 208 Rose = DK 68A37), quoted below pp.304–5. For the general meaning see LSJ s.v.

sense: but it is also used of the attack of armed men and of wild beasts.¹

3. Πληγή or *plaga*, which Simplicius and Cicero attribute to the movement of Democritus' atoms, most likely including their precosmic movement, is a word that is used elsewhere of the blow inflicted from swords, axes and boars' tusks.²

4. ἀλληλοτυπία are applied to Democritus' atoms by Aetius, Alexander and Philo.

Neither word seems to appear outside the context of Atomism. The uncompounded noun τυπία, is most often used with a connotation of violence, to describe the action of a club or hammer, or in battle the blow of a sword, spear or arrow.³

5. According to Galen, the atoms in the void that do not become entangled with one another to form a cosmos, προσκρούει καὶ ἀποπάλλεται.

Ἀποπάλλεσθαι can be used innocently enough of a bouncing ball. It is also used however of a young man hurling weapons, and of blood that has been dispersed by a blow on the skin, and that then 'doubles back' to its place and forms a bruise.⁴

6. The uncompounded verb σ<ύν>-κρουσις in Diogenes of Oenoanda may refer to, or at least include, the precosmic movement of Democritus' atoms.

The simple verb is used to cover a wide range of actions, from 'tapping' to 'knocking' to 'banging'.

¹ The same references as in the preceding footnote.

² Simpl. *Phys.* 42.11 (DK 68A47), quoted above p.165. Cicero, *De fato* 20.46 (DK 68A47), quoted below pp.239–40. For the general meaning see LSJ s.v.

³ Aet. i 12.6 (DK 68A47), quoted below p.223. Alex. *Met.* 36.21–5 (DK 67A6), quoted below pp.211–212. Philo, *De aet. mundi* 8 (= C-W vi 75.8–9). For τύπτω see LSJ s.vv.

⁴ Galen, *De elem. sec. Hipp.* i 2 = i 418 Kühn (DK 68A49). A ball: Sextus Empiricus, *Adv. math.* x 73. Weapons: [Lucian] *Amores* 45 ἀποπάλλειν. Blood: [Arist.] *Probl.* viii 14, 891a3.

The compound verb, προσκρούειν, from Galen, is less common. It is used of banging one's head against something, or in Epicurus of one world colliding with another. It is also used by Plato as part of the wild and turbulent imagery with which he describes new-born creatures, let loose upon the world by the lesser gods, lurching from side to side and 'stumbling against' the elements.

Σύγκρουσις is used of the clash of arms, the ramming of ships, of civil strife, of the attack of armed men.¹

Taken as a whole, therefore, terminology gives little encouragement to any picture of the atoms 'floating freely in the void'.

Rather the reverse: the picture which is indicated in the only sources we have is that of forceful and even violent movement. Clearly, the atoms bang into one another. As Professor Guthrie writes elsewhere, they 'clash' and 'recoil'.²

Conclusion: Alternative Expressions of Weight

The particular significance for the purpose of my argument of this picture of the atoms' movement in the void is that it leaves room, if only conceptually, for the atoms' retention of weight.

When Burnet asks himself—tacitly—how the atoms could have expressed their weight, outside the formation of a cosmos, he assumes that they could have done so only by falling downwards in the void. From this there follows the notion that outside a cosmos the atoms of Democritus, since they do not fall, have no weight. This in turn leads to Professor Guthrie's picture of atoms 'floating freely in the void'.

But if the movement of atoms in the void is forceful and even violent movement, then it is possible, at least conceptually, that weight would be sufficiently expressed by the force with which the atoms collide.

More specifically, differences in the atoms' force of impact could lead to differences in their speed of movement; or differen-

¹ Alex. *Met.* 36.22 (DK 67 A6), quoted below pp.211–12. Diogenes of Oenoanda, fr. 32 col. ii 9 Chilton (DK 68A50). For κρούειν, προσκρούειν and σύγκρουσις see LSJ s.vv. Add Ioannes Malala, *Chronographia* xviii 468 (= *PG* xcvi 681D).

² *History* ii 404 n.1.

ces in the atoms' speed of movement could be effected directly by the atoms' differences of weight.

Thus at least on the level of conceptual possibility there is no need for the atoms to be weightless or to have only potential weight or *Pseudoschwere* simply because they do not fall downwards in the void.¹

Curtailment of the Aristotelean assumption, that weight must be expressed by movement in a specific direction, leaves open the possibility, if only the conceptual possibility, that even when the atoms were moving at random in the void, differences in the weight of atoms could have been expressed by differences in their speed of movement, whether directly or as a result of their force of impact.

In the section which follows I consider what evidence there is that such possibilities were ever realised historically.²

§ 2—

The Nature of Weight: Weight Expressed As Force of Impact and As Speed of Movement

Weight As Force of Impact

(i)

The notion of weight as a factor in the force of impact is little more, initially, than an application of the quite general association of weight with force or violence.

Thus Aristotle writes that animals with a hucklebone in their hind legs are able to use them in self-defence, because the presence of a hucklebone makes the blow of the hind legs 'heavier'

¹ For the origin of the expression *Pseudoschwere* (Liepmann, *Mechanik* 28–30), see below p.352.

² In choosing differences in speed and differences in force of impact as possible expressions of weight for the atoms when they are moving in the void, I do of course already have an eye to what can be instantiated historically: the point is that from the general picture of the atoms' behaviour I am claiming, at this stage in my argument, only a conceptual and not an historical possibility. I leave aside other possible effects that might perhaps be thought of for the atoms' differences in weight, because there happens to be no trace of them historically.

A further caution: the more precise relation between weight and speed, i.e. whether the lighter or the heavier atoms would move the faster, is a question I leave for a later stage in my discussion: see ch.XI § 4, pp.323–9 below.

βαρείας χειρας ἐπ-οίσει, II. i 88–90).

(ii)

We may perhaps doubt whether this notion, of weight as associated with force or violence, can be transferred to the movement of bodies in a void.

That it can be, at least in later thinking, is clear from Lucretius, who writes, ii 83–8:

nam quoniam per inane uagantur, cuncta necessest
aut grauitate sua ferri primordia rerum
aut ictu forte alterius. nam <cum> cita saepe
obuia confluxere, fit ut diuersa repentē
dissiliant; neque enim mirum, durissima quae sint
ponderibus solidis neque quicquam a tergo ibus obstet.

In these lines, Lucretius first presents the atoms as being carried downwards 'by their own weight', *grauitate sua*. But the alternative to this, that the atoms are propelled by a chance collision, *ictu forte alterius*, is then explained on the two grounds, that in the void there is nothing behind the atoms—to stop them being knocked 'backwards'—and that the atoms are both hard and heavy, *durissima . . . ponderibus solidis*. Weight therefore, it would appear, is cause, or accompaniment, both of the downward movement of atoms, and of their collision and recoil.

The former idea reappears in a different guise a few lines later, where the atoms are again said to be moved downwards 'by their own weight', ii 217–18:

corpora cum deorsum rectum per inane feruntur
ponderibus propriis . . .

Thus the two expressions, *ponderibus propriis* (ii 218) and *ponderi-*

bus solidis (ii 88), neatly epitomise the two notions of weight: as cause of movement downwards and as cause, or accompaniment, of collision and recoil.

(iii)

The same two ideas are perhaps to be found in Epicurus. The atoms travel with the same speed, Epicurus tells us, whether (1) they are moving upwards or sideways, if their trajectory is the result of a collision, or whether (2) they are moving downwards as a consequence of their own proper weight

... ἔως <ἀν> ἀντικόψῃ ἢ ἔξωθεν ἢ ἐκ τοῦ ἰδίου βάρους πρὸς τὴν τοῦ πλῆξαντος δύναμιν

The implication in ἰδίου would appear to confirm Lucretius' notion that the alternative, movement resulting from the clash of atoms, is also reckoned as a consequence of the weight of atoms: the movement of an atom is determined by its 'own proper weight', which will carry the atoms downwards, or by that of another.¹

¹ The earlier part of the passage from Epicurus is quoted immediately below. It would be possible to take the disjunction 'movement of either kind' (ἐκὰ- τερον) as being either (1) the disjunction between movement upwards and movement sideways, or (2) the disjunction between these two kinds of movement and movement downwards. I have taken it in this latter sense, although there is then the slight illogicality that whereas (1) a collision could alter the course of an atom that was already moving 'upwards or sideways', as well as of an atom that was moving downwards, nonetheless (2) the reassertion of an atom's 'own weight' can apply only to an atom that was moving 'upwards or sideways', and not to an atom that was already moving downwards.

The idea that weight causes force of impact could perhaps carry with it the converse idea, that weight will cause different degrees of resistance. This idea Furley, *Two studies* 227–33, seeks to extract from Lucretius ii 288–9 ('pondus enim prohibet ne plaris omnia fiant / externa quasi ui') and, wrongly as it seems to me, from the present passage in the *Letter to Herodotus*. Epicurus does say that 'the weight of an atom may counteract the force of a blow from another atom', not, however, in the sense that 'heavier objects are harder to budge than lighter ones' (Furley's expression, p.230), but only in the sense that after a certain period an atom's own weight will reassert itself, and lead to downward movement. Bailey interprets the distinction more or less as I have done, *Epicurus* 218: 'a new collision will start an immediate change of direction, whereas the tendency to move downwards would assert itself gradually and cause a gradual deflexion'.

It is interesting to note that 'the force of impact' (ἡ πλεκτικὴ δύναμις) makes

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Weight As Speed of Movement

(i)

In this same passage, Epicurus' purpose is to attack the idea that atoms would travel with differences of speed in the void, whether as an expression of their intrinsic weight, or as a result of the collision of one atom with another. He writes, *Ep. ad Her.* 61: ἔσται, οὐθ' ἢ κάτω διὰ τῶν ἰδίων βαρῶν.

'What is more, the atoms must have <all> the same speed . . . heavy atoms will not move more speedily than do atoms that are small and light . . . nor will small atoms move more quickly than larger ones . . . nor will there be any increase of speed for atoms that are sent moving upwards or sideways as the result of collisions, or for atoms whose own weight sends them downwards.'¹

(ii)

The idea is repeated by Lucretius, but with the difference that while Epicurus does not say that anyone had actually held such an idea, Lucretius writes more personally, and also adds the notion (which in a moment we shall find again in Alexander) that because the heavier atoms move faster they overtake the smaller ones in the void, ii 225–9:

quod si forte aliquis credit grauiora potesse

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an appearance in the atomist cosmogony recorded by Aetius, i 4 § 2 (DK DK 67A24): the mechanism of ἐκθλιψις ensures that 'the force of impact' grows less as the 'small, round, smooth and slippery atoms' are driven further from the centre by the action of atoms which are 'larger and heavier'. But the explicit mention of the *dine* makes it impossible to use this as evidence in the present argument.

¹ For the possible change of subject in this passage, from atoms to 'bodies in general', see above pp.159–60. For the interpretation of this passage see also pp.325–6 below.

corpora, quo citius rectum per inane feruntur,
 incidere ex supero leuioribus atque ita plagas
 gignere quae possint genitalis reddere motus,
 auius a uera longe ratione recedit.

Bailey suggests that this view may have been adopted by Epicurus' immediate predecessor, Nausiphanes of Teos; but this suggestion is rather weakened by Bailey's failure to appreciate that only in Lucretius, and in Alexander, do the larger atoms catch up the smaller ones because of their greater speed.¹

Since we are reduced to speculation, it seems more likely perhaps, if Lucretius' *aliquis* were ever a creature of flesh and blood, that he was someone later than Epicurus who attempted to avoid the anomaly of the *declinatio* by the postulation of different speeds, while retaining a downward movement of atoms in the void.

However that may be, Epicurus himself does not represent differences of speed and weight as taking the place of a *declinatio*: we have simply the denial that differences of weight are expressed by any increase in speed of movement, whether directly, or as a result of the impact of one atom with another.²

¹ *Greek Atomists* 129. It is only the unthinking conflation of the passages I have quoted from Epicurus and from Lucretius which leads Bailey to write, 129 n.1:

'Since Epicurus . . . is concerned to argue against a theory that the heavier atoms catch up the lighter in their downward fall in the void, it is clear that the idea of weight as the cause of downward motion must have been introduced into the atomic theory before his time.'

It is quite a different matter to argue, as does Zeller, ZN 1089 n.4:

'Denn solche Fragen selbständig zu behandeln, ging weit über das Vermögen des römischen Dichters.'

I should myself be reluctant, on this ground, to attribute to Epicurus even the details of argument found in Lucretius: but I do not pursue the question as it is only marginally relevant to the main tenor of my argument.

² Vittorio E. Alfieri thinks that Epicurus' and Lucretius' arguments are directed against Democritus himself, as Zeller had also supposed, ZN 1089, but at the same time he denies that there was downward movement in Democritus, with the odd result that Epicurus is supposed to have misunderstood Democritus,

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(iii)

Epicurus' own theory, of equal speeds for the atoms, looks very much as though it is the product of arguments which Aristotle deploys in the *Physics* against the possibility of movement in a void, and so against the very existence of void.

Aristotle states two reasons for differences of speed, resistance of a medium and differences of weight.¹ On the first point, he argues at length that movement through a void would be incommensurable with movement through a medium: the implication of the argument is evidently that in a void a body would travel with an infinite speed, an idea which Aristotle would hold to be impossible.² Against the second possibility Aristotle argues much more briefly that shape and size or weight could have no effect upon movement in a void, and that in a void bodies of a different weight would have to travel all with the same speed: equal speeds for bodies of different weight Aristotle evidently assumes would be a sufficient refutation of the existence of void, or at least of movement within a void.³

Movement at a maximum, and therefore a uniform, speed, by atoms which differ in weight, is precisely the consequence of movement through void adopted by Epicurus.⁴

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Atomos idea, l'origine del concetto dell'atomo nel pensiero greco (Firenze, 1953) 81:

'Epicuro (e quindi Lucrezio) ha così grossolanamente frainteso Democrito su questo punto, da attribuirgli una dottrina di cui negli Abderiti non si vede traccia: che il moto degli atomi fosse inteso da Democrito come movimento di caduta verso il basso, causato dunque dal peso . . .'

In his earlier work, *Atomisti*, 93 n.205, Alfieri had denied that Epicurus' criticism was directed against Democritus, although the seeds of the later interpretation are already present, 104 n.247.

¹ Arist. *Phys.* iv 8, 215a25–9.

² *Phys.* 215a29–216a12.

³ *Phys.* 216a12–21. I return in my fourth essay to a closer analysis of this and the preceding argument, and of the assumption, on the relation between the medium and the object moved, which I believe underlies Aristotle's reasoning. Later in this essay (pp.315–17) I return to consider whether Aristotle's argument may be directed specifically against Democritus.

⁴ My argument here presupposes that Epicurus will have known at least the content of Aristotle's argument, Ettore Bignone doubts that Epicurus knew the esoteric works of Aristotle, *L'Aristotele perduto e la formazione filosofica di Epicuro* parti i-ii (Firenze, 1936), reaffirmed in 'La dottrina epicurea del "cli-

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(iv)

From this it follows, rather curiously, that while adopting opposite conclusions Epicurus and Aristotle both argue against the same theory: they both attack the notion that in the void there can be variations of speed resultant upon variations in weight.

This explains Alexander's extension of Aristotle's argument, to form a refutation of atoms' moving in the void, either with differences of speed or with equal speed.¹

1. Aristotle argues, against the idea of bodies travelling at different speeds through the void, that they would have to travel all at the same speed.
2. Alexander argues independently against both alternatives: that bodies cannot travel at different speeds, and that they cannot travel all at the same speed.

(footnote continued from previous page)

namen", sua formazione e sua cronologia, in rapporto con la polemica con le scuole avversarie, nuove luci sulla storia dell' atomismo greco', *Atene e Roma* serie 3 anno 8 (1940) 159–98.

Bignone's view has not won general acceptance, and was challenged soon after its publication by V.E. Alfieri, 'La formazione del pensiero aristotelico e la polemica epicurea', *Sophia* 7 (1939) 224–5, and in *Atomos idea* 82, and by G. Capone-Braga, *Atene e Roma* serie 3 anno 8 (1940) 35–47.

However, for the present purpose this difference of opinion is only marginally relevant, since even Bignone allows that the content of Aristotle's polemic against the atomic theory may have been contained in his published work on Democritus. The point is relevant also to the question of the 'parts' of atoms, cf. pp.270–9 below.

In view of the probability that Epicurus' theory has been designed to circumvent the criticism in Aristotle (—to circumvent, by adopting as rational the conclusion which Aristotle regards as absurd), it seems to me disingenuous to write, as Cornford does, of the 'truth' which 'was divined, without experiment, by Epicurus', Loeb edn of the *Physics* i (London, 1929) 356 n.b, a judgment all too fondly repeated by later writers, e.g. Lane Cooper, *Aristotle, Galileo and the tower of Pisa* (New York and London, 1935) 58 n. 1, W.D. Ross, in his edition of the *Physics* (Oxford, 1936) 591, cf. Guthrie, *History* i 18. The coincidence between Epicurus' belief and the theory of modern classical physics that in a void bodies fall all with the same acceleration is in any case belied by Epicurus' further conclusion that in the void all the atoms move 'with the speed of thought' (*ἄμα νοημάτων*, in the continuation of the passage quoted), a conclusion again fairly obviously designed to circumvent (by accepting) the earlier argument in the *Physics* (iv 8, 215a25–9), where Aristotle's assumption is evidently that in a void movement would have to be instantaneous.

¹ *Ap. Simpl. Phys.* 679.12–22.

Aristotle's argument need not perhaps be directed exclusively against the Atomists. As Brieger pointed out, against Zeller, the definition of void against which the whole series of arguments is directed, is that advanced by 'Democritus and Leucippus and many other of the physical philosophers' (*Phys.* iv 6, 213a34–b1).¹

Alexander's argument, in his own words, quoted by Simplicius, is directed 'against Epicurus, and presumably no less against Democritus and Leucippus, and in general those who claim atoms and void as their starting-points' (*Phys.* 679.13–14: λέγοντας καὶ τὸ κενόν).

(v)

Logically, either alternative in Alexander's argument is of equal force. Nonetheless, from the historical genesis of the argument we could perhaps argue that as the alternative of equal speeds has been introduced to take care of Epicurus, so it is the alternative of different speeds that is reckoned as applying more particularly ἴσως ... πρὸς Δημόκριτον.

The nature of the arguments against either alternative points in the same direction.

1. Against the possibility of atoms' moving with different speeds in the void Alexander argues as Aristotle had done, that size, weight and shape cannot affect speed of movement in a void, *ap. Simpl. Phys.* 679.16–17: τὸ μέγεθος ἢ τὸ βάρος ἢ τὸ σχῆμα πρὸς τὸ τάχος συμβάλλεται.

2. Against the possibility of atoms' moving all with the same speed, Alexander argues that they could never catch each other up, 679.17–18: καταλήπεται ἢ ἑτέρα τὴν ἑτέραν, οὐδὲ ἀλληλοτυπήσουσιν ἢ περιπλακίσονται.

If atoms cannot catch each other up because they are travelling all at the same speed, it must be that they are moving all in the same direction, as they do in Epicurus' system, if we leave out of

¹ Zeller, ZN 1088–9. Brieger, *Urbewegung* 9–10, 'Urbewegung' 592–3.

account for the moment, as does Alexander, the introduction of the *clinamen* for some atoms.

From this we could perhaps again argue that if one of the alternative notions is intended to apply specifically to Democritus, then it must be the other notion, i.e. the notion of atoms moving with differences of speed.

(vi)

Were this attribution to be true in fact for Democritus, we might wonder that Democritus' name is not attached directly to this branch of the alternative, if not by Alexander, then at least by Simplicius, in reporting Alexander's argument.

But examination of Simplicius' behaviour shows that there need be no significance in this omission.

A good deal later in the *Physics*, Simplicius remarks that Epicurus had adopted equality of speed for the atoms, in order to circumvent Aristotle's argument against indivisibility.¹ Thus in the present passage Simplicius knows that it is Epicurus who adopted equality of speed for the atoms, but he does not say so.

It is equally possible that Simplicius knew, or thought he knew, that the earlier form of Atomism, from which Epicurus had deviated, had made the atoms move with differences of speed, but that there was no later occasion for Simplicius to provide a specific attribution for the theory.

Conclusion

For the sake of clarity, I have followed through this series of passages from Aristotle, Epicurus, Lucretius, Alexander and Simplicius, without pausing to calculate the precise value of each item of evidence.

It is apparent that the alternative expressions of weight, as force of impact and as speed of movement, are more than conceptual possibilities. They have some kind of historical reality: but when precisely, and for whom?

¹ *Phys.* 938.21–2.

(i)

The simpler notion, of weight as force of impact, is the easier to locate.

For the later Atomists, at least for Lucretius and perhaps for Epicurus, weight appears to be expressed equally, and independently, by the downward movement of atoms and by their force of impact.

(ii)

The more precise notion, of differences of weight expressed as differences in speed of movement, appears a number of times, but fleetingly, and elusively.

1. In Aristotle, it is impossible, on intrinsic grounds alone, to tell whether the notion that bodies in a void would have to move with greater or less speed according to their weight is introduced only as a means of refuting the notion of movement in a void, or as an element in the original theory that has been selected, and is exploited, for its supposed vulnerability.

2. When Epicurus attacks the same idea, it is again impossible to tell whether he does so only in order the more clearly to establish his own theory, that all atoms move with absolute and uniform speed, or whether possibly his intention is to mark the distance between his own form of Atomism and that of his predecessors.

3. In Lucretius, the theory is cast in a personalised form, but it is impossible to tell whether this is intended historically, or is only a literary device.

Even if it is intended historically, Lucretius presents the notion of differences in speed according to weight as an alternative to the *declinatio*, so that his *aliquis*, if he ever existed, would seem to be someone who set himself up as a rival to Epicurus, and who would not therefore ante-date Aristotle.

4. Alexander does specify Democritus and Epicurus as the targets of his criticism. Moreover, the one member of Alexander's argument, the notion of differences of speed

caused by differences of weight, does align itself, both conceptually and historically, with Democritus.

Even so, Alexander writes only ἀρχὰς τὰ ἄτομα λέγοντας καὶ τὸ κενόν. Both the qualification and the generalisation are typical of Alexander's disinclination to temper pure philosophy with the facts of history.

(iii)

From this sequence of evidence, therefore, it is impossible to prove directly that Democritus or Leucippus held the notion of weight expressed as force of impact or as speed of movement.

Whether in the light of all the evidence as a whole it might be reasonable to project either notion backwards from Aristotle into the fifth century, is a question I shall consider later.¹

For the moment, I shall adopt the far more limited course of completing the series of passages that stem from Aristotle's argument, by returning to the passage in Simplicius where Democritus' atoms are said to move 'because of' or 'in accordance with' their weight.

§ 3—

Weight and Void

(i)

I have already noted that in the passage in the *De caelo* where Epicurus and Democritus are alike said to have attributed weight to the atoms, Epicurus alone is said to identify weight with 'movement downwards according to nature'.²

Democritus' atoms, we learn elsewhere, do not have natural movement; and the implication therefore is that they do not move downwards.³

(ii)

There is the same implication in the passage in the *Physics*,

¹ Cf. pp.211–22 below.

² *De caelo* 269.4–14, pp.161–6 above.

³ *De caelo* 583.20–2, *Phys.* 42.10–11, pp.165–6 above.

which explicitly describes the movement of atoms in the void.¹

I have already argued in favour of Diels' emendation of περιπαλάσσεσθαι. The atoms are 'tossed around': they 'shoot' or 'dart' or 'leap about'.²

If we retain Diels' reading, then it becomes virtually impossible to suppose that in the clause immediately preceding this Simplicius can have intended movement 'by weight' or 'in accordance with weight' to be movement downwards.

An inconsistency of this order, and without any mention even of Epicurus which might help to explain the confusion, is unlikely in the extreme.

(iii)

If therefore weight is not intended as the cause of movement downwards, on Simplicius' understanding of the theory, then we must try to find what other connotation, for Simplicius, the notion of weight, and in particular the expression κατὰ τὴν βαρύτητα, is likely to have held when qualifying the movement of atoms in the void.

If we do so, we find, I think, that the two most obvious connotations, in this context, are precisely those that I have already explored. If weight is not expressed as downward movement, then it is likely to be envisaged, by Simplicius, as force of impact and as speed of movement.

Weight as Force of Impact

(i)

The ostensible reason for Simplicius' introduction of weight at this point is to explain how the atoms can move without an external agency, such as Anaxagoras' mind or Empedocles' Love and Strife.

From the point of view of the immediate context, therefore, κατὰ τὴν βαρύτητα is intended to be in some way a correlative, or an addition, to Aristotle's assertion, in the passage which Simplicius-

¹ Phys. 1318.30–1319.5, quoted pp.166–7 above.

² Pp.167–71 above.

cus is commenting upon, that the atoms move διὰ ... τὸ κενόν (*Phys.* viii 9, 265b24).

The other occasion when Simplicius speaks of the atoms' moving 'in the void', he adds that they do so πλὴγῃ, it seems to me, are intended to be roughly equivalent: the atoms are moved 'by force' because the direction of their movement is determined by their 'hitting' each other, i.e. by their collision and recoil.¹

(ii)

I noted earlier that there are in effect two kinds of movement described by Simplicius in the present passage.

1. There is the primary and 'only' movement: movement in space, or movement from place to place.
2. There are its immediate consequences: the entanglement of atoms one with another, and their separation.

The primary kind of movement, I have argued, is designated by the term περιπαλάσσεσθαι.

But what is there in Simplicius' analysis to explain the prefix περι-?

If the atoms do no more than move 'through the yielding and unresisting void', then there will be no obvious need for them to move 'round and about' or 'from place to place' (περι-).

The prefix therefore I take to mean that even before Simplicius speaks of the atoms as becoming entangled with one another and as being separated from one another he probably thinks of them as in collision: hence (probably) the different directions of their movement.

Has there been nothing then in the preceding sentences to introduce, or to explain, the notion of collision?

Only the expression κατὰ τὴν βαρύτητα. The additional element in Simplicius' description, the movement of the atoms

¹ For these two passages cf. pp. 165–6 above.

'hither and thither' or 'from place to place', is very possibly provided, it seems to me, by the provision that the atoms are moving in the void 'in accordance with their weight'.

(iii)

The two factors that I have spoken of coincide in their effect: the expressions which Simplicius uses elsewhere to describe the movement of atoms, and the particular connotation of the verb which describes the movement of atoms in the present context.

1. 'In accordance with weight' seems to me most simply taken as a more general expression of what is expressed elsewhere as movement of the atoms $\pi\lambda\eta\gamma\tilde{\eta}$
2. The atoms 'dart *hither and thither*' or 'shoot *this way and that*', because of the force of impact occasioned by their weight.

Weight as Speed of Movement

It is possible however to be more specific.

In his commentary on Aristotle's analysis of void in book four of the *Physics*, Simplicius details his own conception of weight, partly in elaboration upon, and partly in correction of, Alexander.

(i)

Alexander argued that equal speed for all the atoms would make it impossible for them to catch each other up.¹

Simplicius counters that it is 'easier' to argue that the atoms cannot move all with the same speed because differences of weight would have to lead to differences of speed, if weight were not to be altogether ineffective, *Phys.* 679.24-32:

If someone asks why a body that is more heavy cannot move with the same speed as a body that is less heavy, an easier answer <than the one given by Alexander> is that if the additional weight does not make the movement any

¹ *Ap. Simpl. Phys.* 679.12–22, esp. 17–18; *cf.* pp.188–90 above.

quicker than weight cannot be the original cause of downward movement in the void.

'For if the addition of something does not intensify or in any way increase the movement then such a factor cannot be the cause of movement originally.

'But if the weight of each body is not in each case the cause of its moving in the void, then in the void bodies would never start moving in the first place, since bodies have no cause of natural movement other than the weight that belongs to each of them.'

The context of this argument needs to be considered carefully.

1. Aristotle, as I noted earlier, argues that in the void the atoms cannot move with differences of speed, and would therefore have to move all with the same speed, a consequence which Aristotle holds to be impossible.
2. Since Epicurus supposed that in the void the atoms do move with the same, i.e. with a maximum speed, Alexander is led to argue against both possibilities independently: the atoms cannot move with different speeds nor all with the same speed.
3. Simplicius, in the passage I have translated, argues that the atoms cannot move all with the same speed, on the ground that a difference of weight must lead to a difference of speed.

By this seemingly slight correction of Alexander's argument Simplicius has come close to *reversing* the order of argument in Aristotle. For by making a refutation of equal speeds depend upon the assumption of different speeds Simplicius no longer excludes, as both Aristotle and Alexander had done, the possibility of the atoms moving with a difference of speed in the void.

(ii)

Simplicius' change of perspective is clarified in the continuation of his commentary. For Simplicius quotes from Alexander an additional argument against Epicurus which turns on the assumption that atoms in the void cannot move with a difference of

speed: Simplicius then replies explicitly that the absence of a medium does *not* preclude the possibility of a difference of speed, *Phys.* 679.32–680.9:

'Alexander also argues that: "(1) If the Epicureans believe that every body has weight, and that bodies move through the void because of their weight; (2) but if things which have weightiness as the cause of their movement are, as a consequence, bound to exhibit a greater speed of movement as the effect of their having a greater weight; (3) if however it is impossible for there to be variations of speed in the void: then it follows that it would not be possible for bodies to be moved in the void because of their weight. But if weight does not move them then they would not move at all.'

'This argument obviously provokes the reply that if bodies have weight as the cause of their movement, and the greater weight as the cause of a faster movement, then why should bodies *not* move through the void?

'For even if something does have the possibility of being both more easily or less easily divided, and if this then acts as the medium for movement, providing <by the greater or less ease of its divisibility> a faster or a slower movement, nonetheless the presence of such a body cannot be accounted the cause of weight.

'The truth is rather that weight may differ, and that if it does so then both the body that is easily divided and the body that is not so easily divided accentuate the difference in the weight of the body that travels according to nature.

'<That is to say, a difference in the medium accentuates the difference of weight, but it does not determine the difference of weight:> for just as other qualities are also increased in extent if, with no change of kind, they are present in a larger substrate, so also the same should follow in the case of weight. <If the body in question has heaviness, then the larger portion will be heavier than the smaller portion, provided that both bodies are of the same kind.>

'Thus as a general principle it is weight that makes a body able to divide a medium, it is not the division of the medium which causes the weight: <weight causes division> whether

or not the medium beneath the moving body <in fact> acts to hinder its passage.¹

(iii)

The sentences I have attempted to paraphrase are remarkable, in Simplicius, for their lack of lucidity. The general purport, however, is clear. Speed, or ease, of division depends only in part on the nature of the object divided. Weight varies, just as other qualities do, in accordance with the larger or smaller quantity of the material available, and independently of the divisibility of the medium.

The confusion—to the modern reader—arises partly because Simplicius still conceives of differences of weight, as Aristotle also had done, as invariably expressed by a difference in speed of movement, and partly because he still clings to the conception of movement as the division of a medium, even though, in the final sentences that I have paraphrased, this leads Simplicius to write of weight as the cause of division even when there is *no* resistance from the medium.

This final, strangled, formula is Simplicius' endorsement, in effect, of the objection that he brings against Alexander. Bodies *are* able to move through the void, because movement, still, paradoxically, conceived of as 'division', is the effect of weight, independently of the resistance of a medium.

This therefore is an important moment in Simplicius' expression of his own ideas. Simplicius rarely takes a direct stand against the authority of Aristotle, at least of an Aristotle interpreted in the light of Plato. He is, however, willing on occasion to diverge from Alexander's interpretation, despite the high regard

¹ In Alexander's argument I have translated both $\rho\omicron\pi\eta$ carries with it an inevitable connotation of movement.

Similarly, in Simplicius' reply I have translated $\tau\eta\varsigma\ \kappa\alpha\tau\grave{\alpha}\ \phi\acute{\upsilon}\sigma\iota\nu\ \rho\omicron\pi\eta\varsigma$ (680.5) as 'the weight of a body that travels according to nature', since the expression clearly includes both weight and the movement of a body according to nature that is determined by weight. For the text of 680.1–4 see the following footnote.

that he has for the most 'scrupulous' and 'authentic' of the commentators on Aristotle (γνησι-ώτερον *Phys.* 80.15). The paradox is that on this occasion, by venturing to oppose Alexander, Simplicius has in fact come round to adopting a point of view which is, on a crucial point, divergent from that of Aristotle.

Aristotle, or so I shall argue later, sees movement not as the simple traversal of a space but as the overcoming of resistance by a force. It is this conception, or so I shall argue in my fourth volume, which lies at the heart of Aristotle's arguments against the possibility of movement in a void. Simplicius, in the final sentences I have translated, takes up, by implication, an alternative standpoint, whereby the presence or the absence of resistance from a medium determines not movement as such, but only the speed of movement. For by allowing the continuance of movement in the absence of resistance from a medium, and therefore, by implication, in the void, and by allowing weight, even without resistance from a medium, to effect a difference of speed, Simplicius comes round, in practice, to adopting precisely the view which Aristotle had initially set out to refute: the possibility of the atoms moving in the void with differences of speed according to their weight.¹

(iv)

Thus for Simplicius movement continues in a void, but without one of the factors, difference in the resistance of a medium, which effects difference of speed. The other factor, weight, remains, as

¹ The earlier part of Simplicius' reply runs, 680.1–4: τοῦτο.

It is of course always possible that a difficult text has been corrupted. If that is not the case here, then is it perhaps too fanciful to suppose that Simplicius' adventurous branching-out from his dependence on Aristotle, and on Alexander, has put his language under strain? In a Note to my fourth essay I shall suggest that Simplicius' position has been adopted as a concession to Philoponus' criticism of Aristotle; this would be an additional reason for Simplicius' unease.

an independent source of variations in speed.

This affects radically the context of Simplicius' account of the movement of atoms 'according to weight' in book eight of the *Physics*.

It is true that in the two passages I have paraphrased from his commentary on book four Simplicius' argument is couched in terms of weight as cause of downward movement, since in either case his critique touches upon Alexander's argument against Epicurus. Simplicius' statement of principle cannot therefore apply directly to the earlier atomic theory.

1. In Simplicius' critique of Epicurus, τῆς κατὰ φύσιν φορᾶς (679.31).

2. In the case of the earlier Atomists, Simplicius has specifically affirmed that the movement of atoms in the void is 'by force', and that the atoms have no natural movement.¹

But by allowing that movement may take place even in the absence of resistance from a medium, and therefore, by implication, in the void, and by allowing that there may be differences of speed independently of the presence of a medium, Simplicius has so far departed from the principles of Aristotle's philosophy that the expression 'according to weight' may have meaning, I suggest, even outside the context of 'natural' movement.

For if we make the necessary adjustment over the direction of movement then it seems to me that Simplicius could very possibly have applied the principles which he expresses in his commentary on book four of the *Physics* to his description in book eight of the atoms moving κατὰ τὴν βαρύτητα: since the movement of the atoms is 'enforced' movement, the atoms do not move downwards, but differences of weight in the atoms will nonetheless still be expressed, even in the void, as differences of speed.

¹ See the passages quoted pp.165 and 192 above.

Conclusion

(i)

Whether or not, or how far, Simplicius' evidence is likely to represent Democritus' own conception of the atoms' behaviour is a question I leave to be answered in consideration of the distribution of evidence as a whole.

For the moment, my conclusion is simply that Simplicius' evidence on Democritus' conception of weight is all of a piece, with no inconsistency, either internally or on the question of movement, that need betray confusion with Epicurus.

1. The atoms have weight, in virtue of their density, and as part of the uniformity of their nature; from their possession of weight there arises, under the action of a vortex, the distinction, or the appearance of a distinction, between heavy and light.
2. The atoms are also said to move in the void 'because of', or perhaps rather 'in accordance with', their weight. However, they are not thereby thought of as moving downwards in the void.

Simplicius' earlier categorisations of the movement of atoms in the void, and the ideological preferences which he has expressed earlier in his commentary on the relation of weight and speed, very possibly indicate that he sees the weight of the atoms at this point as sufficiently expressed in differences of speed, or at least that he sees the random directions of their movement, their 'darting hither and thither', as determined by the 'weight' of their impact.

(ii)

From this it follows that Simplicius, rightly understood, offers no independent support for what I have called the 'current compromise', namely the idea that Democritus' atoms acquired weight only within a cosmos, or within the beginnings of a cosmos, and that in the void the atoms were without weight.

Indeed, it turns out that Simplicius is opposed to that interpre-

tation, both *implicitly* in virtue of the passages where he attributes weight to the atoms in accordance with their density or with the uniformity of their nature, and *explicitly* in the passage where he writes of atoms as moving in the void 'in accordance with their weight'.

Thus the evidence of Simplicius is aligned with, and indeed goes further than, the evidence in Aristotle and in Theophrastus.

1. Theophrastus and Aristotle attribute weight to the atoms, with no explicit specification of whether or not the atoms in question are related to a cosmos.
2. Simplicius, explicitly and by implication, attributes weight to atoms which are outside a cosmos.

Chapter Seven— Diogenes Laertius and Alexander

§ 1— Diogenes Laertius: The Time Sequence

I have examined the passages from Simplicius which Professor Guthrie introduces in favour of what I have called the 'current compromise'. In the first two sections of this chapter I consider very briefly a passage in Diogenes, which Burnet sought to introduce as furnishing positive evidence that atoms outside a cosmos were without weight.

Diogenes Laertius records a cosmogony, in his account of Leucippus, where atoms are separated into their different kinds because they can no longer maintain their previous state of being ἰσόρροπος.

In the first section of this chapter I consider only the former point. Burnet understands ἰσόρροπα as Brieger had done, namely as describing a condition of things entirely prior to the beginnings of a cosmos.²

But this interpretation proves to be hardly possible when we look at the position which this expression occupies in the doxographical material which Diogenes has appended to the very brief biographical note which is all that he can supply by way of a *Life* of Leucippus.³

¹ *EGP* 344–5. The origin, and the nature, of Burnet's argument here are discussed from a broader point of view on pp.359–63 below.

² Brieger, 'Urbewegung' 596: see further pp.359–60 below.

³ Burnet's interpretation of this point is adopted by Bailey, *Greek Atomists* 94. It is questioned by Alfieri, *Atomisti* 4 n. 13, and by Guthrie, *History* ii 407 n. 1. There is a useful analysis, but mainly of the later part of the entry, by J. Kerchensteiner, 'Zu Leukippos A1', *Hermes* 87 (1959) 441–8.

(i)

Diogenes' account contains two blocks of doxographical material, which are easily distinguishable. The first is so sketchy that even Diogenes, or his more immediate source, was evidently dissatisfied with it, and sought out another, and much better extract, joining the two together with the apology, ix 30 (DK 67A1):
 μέρους δὲ ὧδε ἔχει.

This formula serves to give some superficial appearance of literary form to the juxtaposition of the two blocks of material; but even the most cursory inspection shows that the distinction between the two blocks of material is not precisely that claimed between general (ἐπὶ μέρους), for *both* blocks of material are divided into an initial statement of principles and then an account of cosmogony.

1. The first source writes, ix 30: ἤρεσκε δ' αὐτῷ ἀπειραεῖναι τὰ πάντα ... τοὺς τε κόσμους γίνεσθαι...
2. The second source writes, ix 31: τὸ μὲν πᾶν ἀπειρόν φησιν ... γίνεσθαι δὲ τοὺς κόσμους οὕτω...

The true difference between the two extracts is that in the later the account of the cosmogony is much richer and more detailed than in the earlier. It is indeed superior, in its wealth of detail, to the cosmogony which Diogenes has appended to his *Life* of Democritus. From an extreme of poverty Diogenes has provided almost an embarrassment of riches.

(ii)

The phrase in question is part of this second extract, and clearly falls under the rubric 'worlds come into being thus', ix 31 (DK 67A1): σφαιροειδές.

'Worlds come into being thus: a multitude of particles (σώματα), of all kinds of shapes, are sliced off from the endless and are swept into a large and empty space, where they are crowded together in such a way as to bring about the existence of a single whirl.

'Under the influence of this whirl, the particles, as they collide with each other and as they circle around (κυκλού-μενα) in various ways, are separated into different agglomerations of like with like.

'There are so many of them however that they cannot continue their circling movement (ἰσορρόπων): consequently fine atoms are sieved out, as it were, and make their way <back> into the empty space outside <the whirl>, while the atoms that are left behind stay together and as they become enmeshed with each other they move around together, and at the same rate as each other, so producing the first <primitive> structure to have the shape of a sphere.'

The point to note at once here is that the expression ἰσορρόπων is *preceded* by an account of the aggregation of atoms after their separation from the void and their 'formation of a single *dine*'.

(iii)

Thus the first and essential point to note is that the sentence containing ἰσορρόπων falls *within* the account of the cosmogony.

We can be more precise. It is reasonably clear that the action which is described as παντοδαπῶς κυκλούμενα.

For the movement of atoms described in the later sentence is evidently a consequence of the distribution of atoms described in the earlier sentence.

1. In the first sentence, the atoms, or groups of atoms, are described as 'separating to join like with like': χωρὶς τὰ ὅμοια πρὸς τὰ ὅμοια.
2. In the next sentence, 'fine' atoms, or fine groups of

atoms, fly off into the external void, *πρῶτόν τι σύστημα σφαιροειδέες*.

From this, and from the similar phraseology, it follows that the type of movement which *accompanies* the separation of atoms to join like with like will be the same as the type of movement which *precedes* the distribution of atoms between central complex and external void.

1. The atoms which separate to join like with like are described as 'circling around': *παντοδαπῶς κυκλούμενα*.
2. The atoms which eventually divide between central complex and external void do so because they are 'no longer able to be carried around in equilibrium': *ἰσορρόπων ... μηκέτι δυναμένων περιφέρεισθαι*.

The point to appreciate therefore is that *ἰσορρόπων* looks back further than to the situation where the atoms are 'circling around' and where like is joined with like.

This moment is *subsequent* to the 'formation of a single *dine*', and is *subsequent* therefore to the time when the atoms were moving in a void prior to the sequence of events which constitute the formation of a cosmos.

(iv)

Altogether therefore we can distinguish the following stages in Diogenes' account.

1. There is evidently a stage antecedent to the cosmogonical sequence proper, when the atoms are still moving independently in the void. This is clearly implied by the expression: *... φέρεσθαι κατὰ ἀποτομήν ἐκ τῆς ἀπείρου*.
2. A multitude of differently shaped atoms are drawn into a great void. This is the first act of the cosmogony proper.

3. These atoms join together and form a single *dine*.

4. Under the influence of the *dine*, like agglomerates with like, and it is at this stage that the atoms are said to be 'circling' or 'wheeling around' (παντοδαπῶς κυκλούμενα, ἰσορρόπων ... περιφέρεσθαι).

5. Eventually (cf. *μηκέτι*) this process comes to an end: the finer atoms or group of atoms escape, and return to the void; the other atoms stay behind to form a spherical mass.

6. This in turn, we are told in what follows, forms the substance of the earth, and then, under the continuing influence of a *dine*, draws on fresh material from the void to form the substance of the stars.

Conclusion

From this sequence, it follows that *ἰσορρόπων* describes not the atoms which are moving independently in the void, but atoms at an early stage in the production of a cosmos, when they have already been drawn into the formation of a *dine*.

From the condition of the atoms at this time, we have no right to conclude that the atoms were in the same condition prior to the sequence of events leading to the formation of a cosmos.

§ 2—

Diogenes Laertius: The Meaning of *ἰσόρροπος*

The discrepancy in chronology that I have noted between the context of the phrase in Diogenes and Burnet's application of it to the precosmic void is compounded by Burnet's confusion over the meaning of *ἰσόρροπος*.

In his third edition, Burnet writes:

'Now the word *ῥοπή* is a mere leaning or inclination in a certain direction, which is the cause rather than the effect of weight.'¹

The wider inconsistencies in Burnet's processes of thought at

¹ EGP 344–5.

this point I shall touch upon later.¹ For the moment, I consider only the sense of ἰσορροπία

(i)

What is essential, first of all, is that while Burnet sees that there is some association between ῥοπή and weight, he does not appreciate that in a philosophical context this association turns precisely on the Aristotelean conception of weight as defined in terms of movement.

Thus at the beginning of book four of the *De caelo* Aristotle writes, cap. 1, 307b30–3: κείται, πλὴν εἴ τις οἴοιτο τὴν ῥοπὴν εἶναι τοιοῦτον.

'Examination of heavy and light is properly part of our enquiry into movement, in so far as heavy and light are designated as such by their potentiality for natural movement of some kind.

'It is true that equivalent terms have not been established for the actualisation <of these potentialities>, unless perhaps one were to claim that "impetus" (ῥοπή) is a word that serves this purpose.'

This passage shows at once that ῥοπή is weight envisaged in terms of movement.

Burnet does not grasp the significance of this point, because his ideas on early conceptions of weight have left no room for any radical difference between Platonic or Aristotelean and pre-Platonic conceptions of weight.²

Once we make allowance for the possibility of such a distinction, then it is at once apparent that the expression ἰσορροπῶν

¹ Pp.359–63 below.

² Cf. pp.174–82 above.

entails weightlessness or 'absence of weight' only if we associate weight exclusively with movement, or with inclination, 'in a certain direction', as does Burnet.

Thus the only weight which is here denied to the atoms by the use of ῥοπή or ῥοπος, is the Aristotelean conception of weight as movement in a specific direction.

There need be no denial of weight envisaged as force of impact or as speed of movement.¹

(ii)

Even if we leave aside the question of there being alternative expressions of weight to that of movement in a specific direction, it still appears, if we consider more precisely the meaning of the compound expression ἰσόρροπα should be atoms contained within at least the beginnings of a cosmos.

Plato writes in the *Phaedo* of the position of the earth, but in the form of a generalisation, 109A4–6: ἔχον ἀκλινὲς μενεῖ .

Plato's passage exemplifies the case where ἰσόρροπον πρᾶγμα will not travel towards.

'A body which is ἰσόρροπον, placed in the centre of a uniform medium, will have no tendency to incline in any one direction more or less than in any other: it will stay as it is, uniformly placed, without inclining this way or that.'

¹ Aristotle's use of ἰσορροπία has no necessary implication of weight in Greek?

This description is paralleled in Diogenes. The atoms are ἰσόρροπα because they do not yet move in either one of two opposite directions.

1. They do not yet fly off into the external void (χωρεῖν εἰς τὸ ἔξω κενόν).
2. The larger or heavier atoms have not yet settled into a solid ball that in time will form the earth (συμμένειν ...).

It is only in relation to this incipient development of the cosmos, and the distinction therein of centre and circumference, that the description of the atoms being ἰσορρόπων has meaning.

If there were no potential centre to the *dine*, and if the void were not 'the void outside', then the precise meaning of ἰσόρροπος in this context, as the negation of these local references, would be lost.

Thus even if we allow the connotation of weight or of weightlessness to ἰσόρροπος then even so, the only 'weight' which is here denied to the atoms is necessarily that of centripetal and centrifugal movement.

And that distinction is possible only in the early stages of the production of a cosmos. It would not be possible for atoms that were moving at random in an endless void.

Conclusion

The cosmogony recorded by Diogenes is a most valuable and detailed source of information.

As evidence for the lack of weight in atoms that are outside a cosmos, it fails completely.

1. The atoms described by Diogenes are not atoms that are moving independently in the void.
2. The only 'weight' which is denied to them is that of centripetal and centrifugal movement within the beginnings of a cosmos.¹

¹Mabilleau, *Histoire de la philosophie atomistique* 197, attributes to Cicero *De natura deorum* 'I, ch.35' the notion that 'les atomes de Démocrite sont tous égaux en poids, ce que Diogène traduit par l'épithète ἰσόρροποι, qui consacre l'interprétation'.

(footnote continued on next page)

§ 3—

Alexander: The 'Parts' of Atoms

So far therefore we are left with no positive evidence for the notion that atoms outside a cosmos were without weight.

1. The evidence from Diogenes, which Burnet sought to introduce in favour of this view, proves to be irrelevant.
2. The evidence from Simplicius, which Professor Guthrie introduces, proves, on a careful examination, to support the opposite view: that atoms outside a cosmos did have weight.

In this chapter I consider a passage from Alexander of Aphrodisias which does explicitly raise the question of the atoms being without weight.

In the first book of the *Metaphysics* Aristotle writes of Democritus and Leucippus, cap. 4, 985b19–20 (DK 67A6): ἀφεῖσαν.

Alexander comments on this as follows, *Met.* 36.21–8 (only in part DK 67A6): πλέον ἐν τῷ τρίτῳ Περι οὐρανοῦ

Aristotle. 'But on the subject of movement they were as spineless as the others, and quite failed to take up the question of where movement is to come from and how it is to be present in the world around us.'

(footnote continued from previous page)

There is no mention of Democritus in the passage cited, nor does this idea appear in the account which Cicero does give of weight in Epicurus and Democritus in the *De nat. deorum* i 25.69–26.73 (below pp.240–3). I am fairly sure that Mabillean has copied, and confused, a footnote in Pierre-Benjamin Lafaist, *Dissertation sur la philosophie atomistique* (Paris, 1833) 72 n.1. (Another instance of Mabillean's unthinking repetition of ideas from Lafaist is noted below, p. 338 n.3.)

Alexander. 'Leucippus and Democritus are the target of criticism. These two philosophers do specify that the atoms move about by banging into each other and by knocking against each other, but they give no explanation of the origin or principle of movement in bodies that are constituted by nature <i.e. primarily the four cosmic elements>.

'The point is that (γάρ) <the descriptions they do give cannot be accounted an explanation of the origin or principle of natural movement since> movement by collision is forceful, i.e. non-natural, movement, and forceful movement is subsequent <logically and physically> to natural movement.

'Equally they fail to explain where the heaviness in atoms comes from. <Indeed it is impossible, on their theory, for the atoms to be heavy at all, since> the partless <elements> that are recognised conceptually as belonging to the atoms, and that are parts of the atoms, they admit have no weight: but how then <one may ask> could weight <or heaviness> arise from the conjunction of parts that are without weight?

'This point is explored in the third book of the *De caelo*.¹

This is the only passage in ancient literature, other than the entry in Aetius to be discussed in the next chapter, which deliberately indicates that the atoms have no weight. The clipped and episodic nature of the entries in the *Placita*, and the lack of any single authorship, make it particularly difficult to trace the ideological background of the information that is offered there. The present passage is the more interesting therefore in that it provides a sufficient context of argument and allusion for us to be able to determine, with reasonable clarity, the processes of thought which have led to the conclusion that the atoms—or the parts of the atoms—'have no weight'.

Nonetheless, the passage is not mentioned by Professor Guthrie or by Burnet, for Zeller had rightly noted that the conclusion which it embodies rests on ideological considerations that prove

¹Here, as later in an entry in Aetius (*cf.* p.229 n. 1 below), it is possible to interpret βάρος either specifically, 'weight as heaviness', or generically, 'weight as heaviness or lightness'. The argument could be pursued in either way; the difference is not really essential to the sense.

the passage to be unhistorical.¹ This does not mean however that the passage is of no value for our enquiry. In matters of doxography, error has its own significance.

(i)

For the moment I consider only the question of the atoms' having 'parts'.

I have already remarked that Alexander is much more concerned with 'pure' philosophy than is Simplicius.² In this instance, Simplicius tells us, in a remarkably clear and incisive passage, that the atoms of Democritus were without parts, but that, in response to Aristotle's criticism of the theory, Epicurus introduced the notion of conceptually distinguishable *minima* as 'parts' of the atoms.³

In the *Letter to Herodotus*, we find Epicurus' own argument towards, and conclusion that, the atoms have minimal parts, which are only conceptually distinguishable, as a measure of their size. Epicurus concludes, cap. 59: ἀοράτων.

Finally, we should recognise these smallest, and simple, <parts> as marking-points, which starting from themselves as the primal units afford a measure of lengths for things that are larger or smaller <than one another>: this we should recognise by our mental reflection upon the invisibles.⁴

These minimal parts are what are described by Alexander as ἐπινοούμενα ταῖς ἀτόμοις καὶ μέρη ὄντα αὐτῶν. If, therefore, we trust Simplicius, Alexander's argument is at

¹ ZN 1068 n.1.

² P. 192 above.

³ Simplicius *Phys.* 925.13–22, quoted pp.270–2 below.

⁴ The dative in the final phrase should perhaps be understood as purposive and not as instrumental: '... a measure <which we can use> for our mental reflection upon the atoms'. But this, and other difficulties, I leave aside, since the precise interpretation of these chapters from the *Letter to Herodotus* is incidental to my present purpose.

once proved to be unhistorical. Alexander attributes 'parts' to the atoms of precisely the kind that we find in Epicurus, and that, according to Simplicius, were introduced by Epicurus in answer to Aristotle.¹

(ii)

Alexander claims that these parts are without weight. For this idea, he invokes the authority of Aristotle 'in the third book of the *De caelo*'.

The only passage in the third book of the *De caelo* where Aristotle explicitly considers the notion that 'weight arises from the accumulation of elements without weight' is the passage which I have already cited, where Aristotle argues against the production of solid bodies from surfaces.² In this passage Aristotle argues specifically against the thesis named by Alexander, cap. 1, 299b14–15: ἀλλὰ μὴν οὐδ' ἐκ μὴ ἐχόντων βάρος ἔσται βάρος.

But Aristotle is here criticising Plato. How is it then that Alexander applies Aristotle's criticism to the Atomists?

In the section of his commentary immediately preceding the lines I have quoted, Alexander explicitly equates Plato's production of bodies from triangles with the Atomists' production of bodies from 'shapes', *Met.* 36.12–18: πρώτοις σώμασι σχημάτων ἐγένων τὰ ἐξ αὐτῶν.

¹Some manuscripts have the reading: "these—namely Leucippus and Democritus—pursue the same policy *as do the mathematicians*".

¹ The simple historical distinction which Simplicius draws seems to me to survive the controversy over the more precise sense in which the atoms may be said to have 'parts' or to be 'indivisible'. Differing views on this question are taken by Luria, Mau, Vlastos and Furley: the principal arguments are usefully summarised by Leo Sweeney, *Infinity in the Presocratics, a bibliographical and philosophical study* (The Hague, 1972) 161–8, where the appropriate references may be found.

² *De caelo* iii 1, 299a25–300a19, above p.84.

'If this were the <correct> reading, Aristotle would be alluding to Plato, and his point would be to establish a comparison between Plato and the Atomists: Plato attempts to make bodies arise from mathematical entities, and to do so in such a way that the number of the triangles and their difference <in shape> should correspond to the differences in the <sensible> bodies <that Plato hopes to produce from the triangles>; the Atomists, in the same way, working from the differences in the shapes of the primary particles <or atoms> hope to produce <the differences that we see in> the things made out of the primary particles.'

(iii)

However, we can be more specific. Alexander's own commentary on the *De caelo* is lost. But Simplicius quotes from it generously.

Aristotle's second argument against the thesis I have cited from the *De caelo* is that there is no reason for Platonic surfaces to combine in the way required by Plato's theory. The surfaces could as well lie flat on top of each other, instead of edge to edge, which is the only way in which they can be imagined as forming a solid.¹

Simplicius attaches quite some importance to this criticism, since he finds it necessary to defend Plato against Aristotle's criticism. He therefore includes part of Alexander's commentary, since Alexander, he tells us, attempted to attack Plato's theory 'on his own account' (*De caelo* 575.27–8: ἀντιλέγειν πειράται τῷ λόγῳ, ἴδωμεν καὶ τὰ ὅπ' ἐκεῖ- νου λεγόμενα).

The final argument which Simplicius quotes from Alexander is precisely that Plato's theory is reducible to 'the theory of Democritus', *De caelo* 576.10–12: σχήματα εἰδοποιεῖσθαι τὰ φυσικὰ σώματά φησι.

"How then", asks Alexander, "does the theory which claims <to generate bodies> from surfaces <i.e. from trian-

¹ *De caelo* iii 1, 299b23–31.

gles> differ from Democritus' theory, since this <Democritus' theory> also reckons to use differences of shape in order to invest physical bodies with <differences of> form?""

Thus we find here precisely the notion that Aristotle's criticism against Plato is applicable equally to the Atomists, and the explanation therefore of Alexander's reference to 'the third book of the *De caelo*'.

1. Plato is associated with the Atomists because he attempts to derive the differences in sensible substances from differences of shape in the primary elements, as do the Atomists.
2. The association of ideas then flows in the opposite direction, as it were: the Atomists are charged with having attempted to generate bodies with weight from the accumulation of elements that are themselves without weight, in the way that Plato is accused of having done.

By a common fallacy, the comparison that originally leads from A to B picks up a fresh association for the return journey from B to A.

Conclusion: The Double Error

Historically, therefore, there is a double error in Alexander's account of the Atomists at this point.

1. The division of atoms into 'conceptually distinguishable minimal parts' is true not of Democritus, but of Aristotle's criticism of Democritus, and is adopted only by Epicurus.
2. The criticism of 'weight being produced from elements that are themselves without weight' is transferred from Plato to the Atomists, because Democritus' notion of atoms' being identifiable as 'shapes' is held to approximate his theory to the account in the *Timaeus* of the four cosmic elements being constituted from two kinds of triangle.

I speak of error, not of confusion. The conflation of these various ideas by Alexander is the result not necessarily of igno-

rance, and certainly not of any lack of conceptual clarity. It is consistent, and deliberate policy. Alexander sees himself as interested in philosophy, not in history.

§ 4—

Alexander: The Genesis of Error

(i)

I have concluded that Alexander's reference to 'Aristotle in the third book of the *De caelo*' betrays the origin of Alexander's conflation of Plato and Democritus. Simplicius neatly, and sufficiently, refutes Alexander's reduction of Platonism to Atomism.

The Atomists and Plato do have 'shapes' in common. But Plato's surfaces provide a simpler, in the sense of a more radical, hypothesis for the nature of physical phenomena than do the atoms, which are themselves bodies and so fall into the same ontological category as the physical phenomena which Plato's conception of a surface is intended to explain. Plato's treatment of the properties of surfaces, and of the distinction between earth and the other three elements, is also foreign to Democritus' form of Atomism. Simplicius writes, 576.12–19 (immediately following the quotation from Alexander cited above):

σχήμασιν ἐνιδεῖν καὶ τῷ περὶ τῆς γῆς ἁλλοίως διαιτᾶσθαι.

'It has to be acknowledged that from this point of view there is no difference. . . . The difference, I suppose, between the two theories is first that Plato chooses surfaces as the fundamental starting-point for the production of bodies—the atoms are bodies, and a surface is simpler <and more fundamental> than a body; secondly, Plato sees in shapes <not just geometrical figures but> symmetries and analogies with creative force; thirdly, Plato's whole approach to the problem of earth is different.'

Simplicius' methodical, if slightly pedantic, correction of Alexander's loose association of Plato and the Atomists is typical of

the whole difference of approach between the two commentators.

(ii)

Aristotle would have been no less opposed to Alexander's conflation of Democritus and Plato.

In his long account of the genesis of the atomic theory in the second chapter of the first book of the *De generatione et corruptione*, Aristotle does begin by categorising the Atomists and Plato as alike having chosen 'indivisible magnitudes' as their primary elements.¹

But Aristotle's purpose is then precisely to contrast Plato and the Atomists, on the very point that the Platonists' over-speculative approach towards their physical theories led them to posit surfaces as the foundation of the material world, while the Atomists, with their noses closer to the ground, as it were, chose solids as their primary elements, precisely in order to avoid the paradox that any resolution of solids into surfaces would lead to the further resolution of surfaces into points, and so to the impossible requirement that extended magnitudes should be produced from elements that have no extension.²

Aristotle does not speak here expressly of weight. Nonetheless the tenor of his argument is directly opposed to Alexander's conflation of the Atomists and Plato. Alexander's critique of the Atomists in the *Metaphysics* turns precisely on the notion that the Atomists like Plato are committed to the production of bodies which have weight from constituents which have no weight, while Aristotle represents the Atomists as having set out expressly to *avoid* the production of extended magnitude from elements that have no extension.

(iii)

In the *De caelo* Aristotle applies this same distinction to the Atomists and Plato, specifically on the question of weight.

The criticism that the Platonists 'produce weight from the accumulation of elements that are themselves without weight' is

¹ *De gen. et corr.* i 2, 315b24–30.

² *De gen. et corr.* i 2, 315b30–316a14.

picked up by Aristotle in book four of the *De caelo*, in the passage that I have already analysed at length.¹

Aristotle's point in the fourth book, as we have seen, is to *contrast* the Atomists and Plato, specifically on the ground that the Atomists, unlike Plato, do *not* reduce the constituents of the physical world to elements that are themselves lacking in weight.

(iv)

Even by the lax standards of Aristotle's criticism, the lack of historicity in Alexander's account of the Atomists is therefore wholly clear. His error, nonetheless, remains of extreme interest.

First, Alexander does not write explicitly that the atoms were in fact without weight. His argument falls into three parts.

1. The Atomists do not say how weight accrues to the atoms: *ἄτόμοις λέγουσι*.
2. They 'do say' that the parts of the atoms are lacking in weight: *καὶ μέρη ὄντα αὐτῶν ἀβαρῆ φασιν εἶναι*.
3. If their constituent parts are lacking in weight, then how can the atoms themselves have weight?

The implication intended is clearly that the atoms cannot, and do not, have weight. But it is an implication arrived at by argument, and expressed in the form of a rhetorical question.

(v)

A second, and more important, point. I have charted the more general ideological shifts by which Alexander arrives at this conclusion. But what is the more particular preoccupation which has, so to speak, sparked off this line of thought?

It is Aristotle's belief that violent or non-natural movement must be subsequent to natural movement. This belief underlies many of Aristotle's arguments. It is explicit in the *Physics*, in his attempt to demonstrate that movement in a void is impossible.

¹ *De caelo* iv 2, 308b35–309a2, above ch.III § 1, pp.80–100.

The premiss to part of this demonstration is stated as follows, *Phys.* iv 8, 215a1-6:

'All movement is either movement by force or natural movement. If there is forceful movement, there must exist also natural movement. For movement by force is contrary to nature; and movement that is contrary to nature is subsequent (ὕστερα) to movement that is according to nature. It follows therefore that without a natural movement for each of the bodies that are constituted by nature <i.e. primarily the four cosmic elements> no other movement will exist.'

Alexander uses this premiss to justify, and to explain, the assertion in the *Metaphysics* that the Atomists failed to provide a cause of movement.

1. Thus Alexander first asserts that the atoms' movement is determined by their collision and recoil (οὗτοι γάρ ...).
2. Since this movement is enforced movement, and since (on Aristotelean principles, as enunciated in the passage I have quoted from the *Physics*) enforced movement can exist only subsequently to, and requires as an antecedent, natural movement, Alexander concludes that the Atomists have failed to specify a cause of movement (πόθεν μέντοι...).
3. Finally, Alexander concludes that just as the Atomists do not specify a cause of movement, so also they fail to specify the origin of weight (οὐδὲ γὰρ τὸ πόθεν ...).

On this last point, the very parallelism of the phraseology helps to betray the ideological motivation of the conclusion.

1. Of movement Alexander writes: πόθεν μέντοι ἡ ἀρχὴ τῆς κινήσεως τοῖς κατὰ φύσιν, οὐ λέγουσιν.
2. Of weight he writes: οὐδὲ γὰρ τὸ πόθεν ἡ βαρύτης ἐν ταῖς ἀτόμοις λέγουσι.

Once the Aristotelean context of the argument has been made clear, then the implication of this passage is reasonably clear, or so it seems to me: because the atoms have no cause of movement, or more specifically no cause of natural movement, Alexander

supposes that *pari passu* the atoms can have no cause of weight. The assumption is fairly clearly that weight would be a cause of natural movement, and conversely, that since the atoms move at random in the void, they can have no natural movement, and that <therefore> they can have no weight.¹

Conclusion

Alexander himself stops short of asserting unequivocally that the atoms have no weight. Indeed elsewhere, in his treatment of the relation between speed and movement, Alexander does use the atoms' possession of weight as a premiss for a different form of refutation of atomic movement, as we have seen.² The implication of the present argument, that the atoms have no weight, is solely for the purpose of the criticism more immediately in hand.

Nonetheless, Alexander's argument is important for our purpose, precisely because his interest leads him to exploit the principles of Aristotle's kinetics with so demonstrably loose a regard for the facts of history. Alexander's critique, if I have uncovered its presupposition correctly, will show in an especially clear and blatant form the processes of thought which can lead to a denial of weight to the atoms.

¹ I have chosen the passage from the *Physics* to illustrate the point about the priority of natural movement, because it is the most explicit and because it will have a particular use later for a parallel passage in Aetius (*cf.* pp.232–3 below); my purpose is not to suggest that this or any other single passage is necessarily the source of Alexander's argument. It is worth noting that twice elsewhere Aristotle repeats his point that the Atomists have failed to specify the cause of movement, and that each time his accusation is attached, directly or by implication, to the 'priority' of natural movement: see *Met.* 6, 1071b31–4, and for the implication that natural movement is prior *cf.* 1071b34–7; *De caelo* iii 2, 300b8–11, for the priority of natural movement *cf.* 300b11–16; for both passages *cf.* p.237 below.

The absence of natural movement for the atoms, and the association implied with Plato by the reference to the *De caelo*, seem to me all that is needed to explain the charge of weightlessness. D. Furley attempts to introduce the idea, which he claims to find in Epicurus and in Lucretius, that the 'parts' of atoms are in themselves incapable of movement, 'Aristotle and the Atomists on infinity', *Symposium Aristotelicum* 4 (Heidelberg, 1969) 90 n.5. But Alexander does not write of the atoms, or their parts, as being without movement: his point is that the atoms do have movement, but that it is movement 'by force'. Furley finds the passage 'otherwise inexplicable', only because he has not reflected sufficiently on the association of weight with movement in Aristotle's philosophy, and because he has not followed up Alexander's reference to 'the third book of the *De caelo*'.

² *Ap. Simpl. Phys.* 679.14–18, pp. 188–90 above.

'If the atoms had weight, they would have natural movement. Since they have no natural movement, they can have no weight.'

The lesson of Alexander's argument is the easier to appreciate because its authority, from an historical point of view, is obviously nil.

Chapter Eight— Aetius and Cicero

§ 1— Aetius: The Explicit Denial

I turn therefore to the group of three passages, from Aetius and from Cicero, which I alluded to in my first account of the 'current compromise', and which alone are left to provide any positive basis for the notion that outside a cosmos Democritus' atoms are without weight.¹

I take first the entry in Aetius which explicitly denies that Democritus gave the atoms weight, i 12.6 (DK 68A47): *ὑπάρχειν ἄτομον*.

'Democritus says that the primary particles—the "full ones" as they were <in his philosophy>—have no weight, but move by collision in the endless. He further claims that it is possible for an atom to exist as large as a world.'

At this point, it is not my intention to try to decide whether we should accept this statement in Aetius as contradicting, or at least as qualifying, the evidence which we have studied hitherto, from Aristotle, from Theophrastus and from Simplicius.

In order to clear the way for that decision, all I wish to do here is to indicate how the kind of argument that we have seen already

¹ Aet. i 12.6, i 3.18, Cicero, *De fato* 20.46 (all DK 68A47): cf. pp.153–4 above. The three passages are taken together without any distinction of meaning, by Diels, *Dox.* 219–20, Zeller, *ZN* 1068 n. 1, Hamelin, 'La pesanteur de l'atome' 196, Burnet, *EGP* 341–2, and others.

One other passage in Cicero (*De nat. deorum* i 26.73 = DK 68A51, 'quid est in physicis Epicuri non a Democrito?') has been taken to mean that Democritus' atoms were without weight: see below pp.240–1.

Liepmann takes this latter passage of Cicero, together with the two entries in Aetius, as his primary evidence that the atoms have no weight, *Mechanik* 31–3 and 49. Cf. pp.240–1 below.

at work in Alexander *could* have occasioned the denial by Aetius that the atoms of Democritus had weight.

(i)

Apart from Alexander, the effect of Aristotle's ideology of movement on the doxography of the Atomists is perhaps most plainly seen in Simplicius.

In Aristotle's own philosophy, the four cosmic elements move always and only to their 'natural' places, provided they are 'left to themselves' as we should say, i.e. if they are subject to no interference from without: thus fire moves to the circumference of the universe, earth to the centre, and air and water to positions intermediate between these two. Aristotle argues against earlier thinkers, specifically including the Atomists, that in a void, and especially in an endless void, there can be no such distinction of place, and that therefore in a void natural movement is impossible.¹

Simplicius takes this criticism a step further. Since (on the usual interpretation) the atoms of Democritus and Leucippus move in all different directions in the void, and since more particularly the direction of the atoms' movement in the void is determined by their collisions, Simplicius draws the two related conclusions that the atoms are 'without natural movement' (βίη, πλῆγῃ).²

This does not mean that Simplicius holds that the atoms are somehow at first 'stationary' and are then are moved by force, which is how Bailey appears to understand his formulation.³

In writing that the atoms are 'without natural movement', Simplicius appreciates that this is a logical construction cast upon the

¹ This summarises *Phys.* iv 8, 214b12ff., esp. 215a1–14. The whole series of arguments against the void commences at iv 6, 213a12ff.; Democritus and Leucippus are included as the target of criticism, 213a34–b1, cf. pp.189 above.

² *Phys.* 42.10–11 (DK 68A47). *De caelo* 583.20–2 (DK 67A16). Cf. pp.165–6 and 192–3 above. For this interpretation of the movement of atoms in the void cf. p. 163 above.

³ *Greek Atomists* 131: Simplicius 'maintains that "the atoms which are naturally stationary (!) are moved by a blow"' (Bailey's own exclamation mark). F. Pillon also supposes that the atoms are 'inertes par nature', 'L'évolution historique de l'atomisme', *L'année philosophique* 2 (1891) 122 n.2: see further p.239 n.1 below. There is the same implication in Goedeckemeyer, *Epikurs Verhältnis* 122.

These authors have perhaps been influenced by the additional feature in Aristotle's argument in the *Physics*, iv 8, 215a4–6, that without natural move-

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atomic theory, at least in the sense that he appreciates that while the atoms are without natural movement they are never in fact at rest. For in the passage where he speaks of the atoms as moving 'by force', he also speaks of them as being in fact always in movement (*ἀεὶ κινεῖσθαι ... βίᾳ*, *De caelo* 583.21–2).

This same feature of the theory Simplicius emphasises at an appropriate point in the *De anima*. The argument has been that the Atomists may want to explain the movement of the body by the movements of the atoms inside it, but how do they then explain the body's keeping still? They cannot explain it by the departure of the soul-atoms from the body, for that would be death, and they cannot explain it by the atoms themselves being motionless. Simplicius continues, 39.28–31: *κινεῖσθαι κίνησιν*.

'For Democritus and his associates did not think that there would <ever> be a lack of motion in <any of> the atoms; <on the contrary,> their purpose was to have the atoms always in motion; nor more particularly would it be possible <on their theory> to claim a lack of motion for the soul-atoms in the body, since <on their view> the only motion that the animal has is the motion of the soul-atoms.'

Thus it is true that in Simplicius' two accounts of the Atomists, in the *Physics* and in the *De anima*, there is an appearance of contradiction.

1. In the *Physics*, Simplicius writes that the atoms are *ἀκίνητα*.
2. In the *De anima*, he denies that the atoms can be subjected to *ἀκίνησις*.

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ment there can be no movement at all. The same conclusion is reached from a slightly different point of view in the *De caelo* i 7, 276a10. This conclusion, as we shall see, may have influenced the author of the earlier extract in Aetius: cf. pp.232–3 below. But it is not this conclusion which is repeated by Simplicius.

But this appearance of contradiction is an appearance only. The point to appreciate is simply that, for Simplicius, the atoms are 'without *natural* movement': the feature of the theory which Simplicius is concerned to establish in the *Physics*. This does not mean that the atoms are ever in fact at rest: the point which Simplicius is concerned to establish in the *De anima*.¹

(ii)

Soil and season are ripe for a similar association of ideas to have influenced the entry in Aetius which explicitly denies weight to the atoms.

The entry in Aetius immediately preceding the denial of weight concerns Epicurus. The first part of this preceding entry, which again speaks of weight, is unfortunately too garbled to be usefully reconstituted for our present purpose. However, in the second part of the entry, Aetius distinguishes three kinds of movement for the atoms, i 12.5: *τοτὲ δὲ κατὰ παρέγκλισιν, τὰ δὲ ἄνω κινούμενα κατὰ πληγὴν καὶ ἀποπαλμόν*.

These three kinds of movement faithfully represent, if in a somewhat mechanical form, the three kinds or causes of movement that do in fact find their place in Epicurus' philosophy.

1. Epicurus' atoms move downwards because of their weight: this is movement *κατὰ στάθμην*.

¹ I could have simplified my discussion by excluding the passage from the *De anima*, on the ground that that treatise is not by Simplicius. That was the opinion of Piccolomini, *Commentarii in libros Aristotelis De coelo, ortu et interitu; adiuncta lucidissima expositione, in tres libros eiusdem de anima, nunc recens in lucem prodeunt* (Moguntiae, 1608) 1001–3. The same thesis has recently been revived by F. Bossier and C. Steel, 'Tekststudie: Priscianus Lydus en de *In de anima* van Pseudo(?)-Simplicius', *Tijdschrift voor Filosofie* 34 (1972) 761–822.

However, as Madame Hadot has shown, in a paper delivered at the *Centre Léon Robin* of the Sorbonne under the auspices of the *Centre National de la Recherche Scientifique*, the arguments of Bossier and Steel are not conclusive, whether taken singly or as a whole. Her conclusion is not that the *De anima* must be by Simplicius: the question remains an open one.

I have chosen to treat the *De anima* here as a genuine work of Simplicius, not because I am convinced that it is so, but for the sake of completeness, and because the appearance of inconsistency that I have sought to examine would in any case still exist between the *Physics* (*ἀεὶ κινεῖσθαι*).

2. The atoms must therefore swerve, if there is to be the entanglement of atoms needed for a cosmogony: this is movement *κατὰ παρέγκλισιν*.

3. Because of this, the atoms hit one another and rebound: this is movement *κατὰ πλῆγῃν καὶ ἀποπαλμόν*.

There is however one slight, but telling, difference. For Epicurus the *third* kind of movement leads equally to movement upwards and to movement sideways. Aetius specifies only movement upwards.¹

The reason for this slight, but significant, discrepancy is fairly certainly that on Aristotelean principles movement sideways is invariably the result of force, and that from an Aristotelean point of view therefore the peculiarity, and the anomaly, in Epicurus' theory lies not in the explanation of movement sideways, but in the use of the same principle to explain movement upwards, which in Aristotle's system is (for elements that have lightness) an expression of natural movement.

(iii)

For Epicurus there are three kinds or causes of movement. For Democritus there is only one. For Democritus, movement downwards as well as movement upwards or sideways is the result of collision (*κατ' ἀλλήλοσυπίαν*): and there is therefore no need for a swerve of atoms.

From an Aristotelean point of view this means that the one instance of natural movement in Epicurus' system, movement downwards, the *first* kind of movement listed by Aetius, has been engrossed into the *third* kind of movement, movement 'by force'.

At the same time, for an Aristotelean writer, 'natural' movement is movement that is caused by weight. Thus for Epicurus, or at least for Lucretius, weight is cause both of an atom's downward movement and at the same time, or so it would seem, cause,

¹ For example, in the passage quoted earlier, *Ep. ad. Her.* 61, pp.184–5 above, the disjunction lies between movement upwards or sideways and movement downwards: '... nor will there be any increase of speed for atoms that are sent moving *upwards or sideways* as the result of collisions, or for atoms whose own weight sends them *downwards*'.

or at least accompaniment, of one atom's collision with another.¹ But for an Aristotelean writer weight or heaviness will have been associated exclusively with the 'fall' of atoms. And this is precisely the type of movement that in Democritus' system is suppressed.

For Democritus, therefore, the argument of the author of the *Placita* in this entry *could* have been:

'The primary bodies have no weight <for if they had they would have natural movement and would move downwards, as they do for Epicurus, but in fact> they move by bouncing off one another.'²

If this, or anything like it, has been the genesis of the assertion that the atoms 'have no weight', then that assertion is as valueless, historically, as the equivalent assertion in Alexander, and as valueless, historically, as is Simplicius' milder assertion that the atoms 'have no natural movement'.

For in Alexander as in Simplicius the lack of natural movement, and in Alexander the additional denial of weight to the 'parts' of atoms, is simply the expression, in Aristotelean terms, of the lack of downward movement.

Conclusion

The entry in Aetius which explicitly denies weight to Democritus' atoms is preceded by an account of Epicurus which, by a slight but significant touch, betrays the influence of Aristotelean ways of thinking: Epicurus' atoms move upwards 'by force'. In fact, Epicurus himself tells us that they move upwards *and* sideways 'by force': but it is upward movement alone which to the author of the *Placita* signals the lack of Aristotle's conception of fire as moving upwards by nature.

Have Aristotle's ideas also determined the denial of weight to Democritus' atoms in the entry immediately following? Aristotle had argued that natural movement in a void is impossible. Simplicius

¹ Cf. pp.183–4 above.

² Essentially the same interpretation of this entry is given by Brieger, *Urbewegung* 12–13, and 'Urbewegung' 596: 'Mann schloss dann einfach: Was im Leeren nicht fällt, das hat keine Schwere'. For the general context of Brieger's interpretation see pp.351–4 below.

cus concludes that Democritus' atoms are 'without natural movement'. Alexander takes the same train of thought a stage further. The atoms have no natural movement, nor any cause of natural movement. How therefore can they—or their 'parts'—have weight?

If this same association of ideas has influenced the author of the *Placita*, then the weight, or more specifically the heaviness, that is denied to the atoms will be no more than the weight or heaviness which would require atoms to move downwards in the void: conversely, the absence of 'weight' in this sense will be no more than a corollary of the atoms' random movement in the void.¹

§ 2—

Aetius: The Implicit Denial

In the entry that we have just considered, there is an explicit denial that Democritus gave the atoms weight. This same denial has been taken to be implicit in an earlier entry, i 3.18 (in part DK 68A47): σώματα τῇ τοῦ βάρους πληγῇ ἐπεὶ οὐ κινήθεται .

'Epicurus . . . followed in the footsteps of Democritus, in so far as in his philosophy he claimed that the principles of existing things were bodies <or particles> that could be known only by a process of mental inspection. . . .

'These particles moved in empty space, and through empty space: the empty space <through which the particles move> is itself endless <in extent>, and the particles <which move through the space> are endless <in number>.

¹ I specify 'weight' (βάρους) as 'heaviness'; it would of course be possible to understand the term generically, 'heaviness *or* lightness', and in that case the argument I have outlined would have to be made more elaborate, but in principle it would be little different.

'Attaching to the particles there are three characters <or accidents>: namely shape, size and weight. Two of these were introduced by Democritus, namely size and shape. To these Epicurus added the third, weight.

'Epicurus' argument was that the bodies had to be moved by the blow from their weight; <otherwise> they would not move <at all>. <Hence weight is no less important as a primary character of atomic substance than is shape or size.>¹

In this entry, the denial of weight is only implicit, if it exists at all. But at the same time there is a richer context of argument and allusion, from which more of the writer's processes of thought can perhaps be discerned than in the later and shorter entry.

Weight and Movement

(i)

In this earlier report, the accounts of Democritus and of Epicurus are actually interwoven, one with the other.

In particular, the structure of the argument which Aetius applies here to Epicurus is very similar to the structure of the argument which Simplicius employs when he writes of Democritus' atoms as being 'without natural movement'. There is only the accidental variation that the two elements in the argument are put the other way round.²

1. Aetius: ἀνάγκη γάρ, φησί, κινεῖσθαι τὰ σώματα τῇ τοῦ βάρους πληγῇ...

Simplicius: τὰ ἄτομα πληγῇ κινεῖσθαί φησιν

2. Aetius: . . . ἐπεὶ οὐ κινήσεται

Simplicius: Δημόκριτος φύσει ἀκίνητα λέγων τὰ ἄτομα ...

¹ This entry is repeated in Eusebius, *Praep. evang.* xiv 14.5. For earlier interpretations of the passage see above pp.153–4 and 223 n.1.

² *Phys.* 42.10–11 (DK 68A47), cf. p.165 above.

There are two differences of substance.

1. Aetius adds τῇ πλῆγῃ.
2. Where Simplicius argues that Democritus' atoms are moved by force and are therefore without *natural* movement, Aetius writes that unless Epicurus' atoms were moved τῇ τοῦ βάρους πλῆγῃ they would not move *at all*.

(ii)

These two differences will, I think, carry with them one other.

When earlier in the same entry Aetius writes of Epicurus' atoms that they move 'in the void and through the void', the duplication of the expression seems to me very likely to be a reference to the downward movement of Epicurus' atoms.

If so, this same qualification, it seems likely, will most probably be in the compiler's mind when he writes, in the later sentence, κινεῖσθαι ... τῇ τοῦ βάρους πλῆγῃ. The movement envisaged will be movement downwards, and the purport of the argument will therefore be that:

'The atoms move *downwards* because of the force or impact of their *weight*.'

This would explain the *first* difference of substance between the two arguments, that in Aetius and that in Simplicius.

1. 'Force' or 'impact', in Simplicius' account of Democritus, produces movement, but not 'natural' movement.
2. The 'force' or 'impact *of weight*', in Aetius' account of Epicurus, produces not only movement, but 'natural' movement, i.e. movement *downwards*.¹

¹ The expression τῇ τοῦ βάρους πλῆγῃ in Aetius, looks rather like a doxographical formula, designed to highlight at once the similarity and the difference between Epicurus' theory and that of Democritus: for Democritus, the atoms are moved 'by impact'; for Epicurus, the 'impact' is the impact of the atom's own weight, acting from within as it were. On the other hand, the idea of weight as an impact from within does perhaps correspond sufficiently well to the teaching of the *Letter from Herodotus*, where an atom continues on its path until

(footnote continued on next page)

(iii)

But why does the author of this extract suppose that—according to Epicurus—the atoms which were not moved by weight would not move at all—the *second* difference of substance between the argument in Aetius and that in Simplicius?

Initially, the answer to this lies, I would suggest, in the three types or causes of movement listed in the later pair of entries (i 12.5–6). In the first entry of this pair, the movement of the atoms 'by their collision and rebound' is listed subsequently to, and is causally dependent upon, the 'swerve' of the atoms, and this in its turn is listed subsequently to, and requires as a prior stage, a 'fall' of atoms. To reverse the sequence: the 'fall' of atoms is primary, in the sense that without a 'fall' of atoms there would be no swerve, and therefore no collision or rebound. From this we might properly conclude that if the atoms were not moved 'by the blow of their weight', and if therefore there were no 'fall' of atoms, then there would be no movement at all.

At the same time, the conclusion that without weight there would be no movement may be seen as implicit in the argument that I quoted from Aristotle's *Physics* in my account of Alexander.¹ In the *Physics* Aristotle argues that if there is to be violent or non-natural movement there must first be natural movement, for violent or non-natural movement is subsequent to natural movement; from this Aristotle concludes that if there is no natural movement then there cannot be any other movement at all (iv 8, 215a1–6: note especially . . . οὐδὲ τῶν ἄλλων ἔσται κινήσεων οὐδεμία).²

Hence, or so I would suggest, the *second* difference of substance between the argument in Aetius and the argument in Simplicius.

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'knocked aside either from without or from its own weight <reacting> against the force of the atom which struck it'

... ἕως <ἂν> ἀντικόψη ἢ ἔξωθεν ἢ ἐκ τοῦ ἰδίου βάρους πρὸς τὴν τοῦ πληζαντος δύναμιν cap. 61, cf. pp.184–5 above).

Very curiously, Bailey uses what Aetius says of Epicurus in order to attribute to Democritus the idea of 'weight as a kind of internal blow', while he rejects precisely this implication of the *Letter to Herodotus* in his account of Epicurus (contrast *Greek Atomists* 131, cf. 134, and *Epicurus* 219).

¹ Cf. pp.219–21 above.

² There is a similar conclusion, *De caelo* i 7, 276a10 (..κίνησις οὐκ ἔσται). For Bailey's error in attributing this conclusion to Simplicius, see pp.224–6 above.

1. Simplicius recognises that however contrary it may be to the principles of Aristotle's philosophy the primary movement of the atoms for Democritus is movement 'by force'; the atoms move in all directions and are deprived only of natural movement.
2. Aetius, I would suggest, adopts a more extreme interpretation of the Aristotelean principle that natural movement is prior to movement by force, whereby the collision and rebound of atoms is subsequent to, and is dependent upon, the swerve and the fall of atoms: so that if there is no 'fall' of atoms there can be no movement at all.

(iv)

If these, or similar, arguments do provide the context for the entry in Aetius, then the association of downward movement with weight could again be argued to have worked in the reverse direction, so to speak, for the writer's ideas about Democritus:

'If the atoms have weight, they will fall, as they do for Epicurus. <But Democritus' atoms have no natural movement downwards: they are therefore not moved by weight.>'

If this, or something like it, has been the process of thought in the mind of the compiler, then any implication that Democritus' atoms have no weight will again be as valueless, historically, as is Alexander's conclusion relating to the 'parts' of atoms, and as valueless, historically, as is Simplicius' milder conclusion that the atoms are 'without natural movement'.

The status of weight

But there is perhaps another and more specific factor which explains the difference between the two entries in the *Placita*.

The difference between the two entries is not simply that in the one entry Democritus' atoms are explicitly said to be without weight, while in this earlier entry the lack of weight is only implied. For while the later entry is concerned essentially with movement and with weight, what is at issue in this earlier entry is not so much the existence of weight, as the status of weight.

'There are three characters (συμβεβηκέναι) that appertain to bodies: shape, size and weight. Democritus claimed two of these: shape and size. To these Epicurus added the third as well: weight.'

If we pursue the implication of this distinction, and association, of weight and size or shape, we shall see that it is not a quibble to claim that when Epicurus is said to have 'added weight' to the atoms this need not mean that Democritus' atoms were without weight.

Democritus

(i)

Aristotle regularly speaks of Democritus' atoms as differing in 'shape, position and arrangement'. It is clear, at once from the frequency of the formulation and from the terminology which Aristotle attaches to it, that this formulation was part of the original expression of the theory.¹

On the other hand, there is an obvious conceptual distinction between shape, as an intrinsic character of the atoms, and position and arrangement which can be expressed only in terms of the relation of one body to another. Aristotle therefore frequently speaks of the atoms as being 'defined by shapes' (σχήματι διαφέροντα μόνον).²

Size appears only infrequently in Aristotle's characterisations of atomic substance. In the *Physics*, atoms are reckoned to be 'a single underlying substance, distributed as particles differing in

¹ *Phys.* i 5, 188a22–6 (DK 68A45). *De gen. et corr.* i 1, 314a21–4 (DK 67A9), i 2, 315b6–15 (DK 67A9) and 315b30–316a10 (only in part DK 68A123). *Met.* A 4, 985b10–19 (DK 67A6), H 2, 1042b11–15 (the text is not in DK). Position and arrangement only: *De gen. et corr.* i 9, 327a18–19 (DK 68A38). Also Theophrastus *ap. Simplicius Phys.* 28.15–19 (DK 68A38).

² *De caelo* i 7, 275b31–2 (DK 67A19). *De gen. et corr.* i 8, 325b17–19 (not in DK). For similar formulations: *Phys.* i 2, 184b20–2 (*cf.* DK ii 115.7 note), *De caelo* iii 4, 303a10–12 (DK 67A15), *De gen. et corr.* i 8, 325b25–9 (DK 67A7) and 326a14–15 (not in DK).

size and in shape' (τὸ κοινὸν σῶμα ... μεγέθει κατὰ μόρια καὶ σχήματι διαφέρον) .¹

Finally, in the *De caelo*, as we have seen, size is attached to weight: 'the larger <atom> is the heavier'.²

(ii)

In Theophrastus' account of Democritus in his preliminary survey of earlier theories of *sensibilia* in the *De sensibus*, we find the regular grouping of shape, position and arrangement, which are familiar from Aristotle as the primary *differentiae* of atomic substance.

To these is added size, cap. 60 (DK 68A135): τὰ δὲ τοῖς σχήμασιν, ἔνια δὲ τάξει καὶ θέσει διορίζει.

Only when Theophrastus turns to individual theories, and first to Democritus' theory of heavy and light, do we find weight added as a consequence of, or at least as in some way secondary to, and derivative from, size, cap. 61: Δημόκριτος.³

(iii)

This distribution of material, in Aristotle and in Theophrastus, makes it sufficiently clear that weight was not accounted by Democritus as equivalent in status to size and shape.

It is clear therefore that we are entitled to exclude weight, as a *primary* character of atomic solids, since it is in some sense reducible to size.

At the same time, position and arrangement, as I have noted, can be expressed only in terms of the relation or comparison of one body with another: they too can reasonably be excluded therefore from a list of what the writer of the *Placita* reckons as the intrinsic characters or properties of bodies, in effect τὰ συμβεβη-κότα τοῖς σώμασι.

¹ *Phys.* iii 4, 203a33-b2 (DK 68A41). Cf. Arist. *ap. Simpl. De caelo* 295.7–8 (fr. 208 Rose = DK 68A37).

² *De caelo* iv 2, 309a1–2 (DK 68A60), pp.80–100 above.

³ For my paraphrase of these two passages cf. pp.127 and 131 above.

The compiler of the *Placita* is therefore entirely right, if we take Theophrastus and Aristotle as sufficient standard of orthodoxy, to list shape, or shape and size, as the only *primary* characters of atomic solid recognised by Democritus.

Epicurus

(i)

Epicurus, on the other hand, apparently raised weight to the status of shape, for a character in one of Plutarch's dialogues remarks, *Adv. Col.* 1110F: τὸ σχῆμα καὶ τὸ βάρος αὐτοὶ τῆς ἀτόμου λέγουσι.

'My purpose is not to contradict his argument, but merely to observe that the beliefs he has quoted are as inseparable from Epicurus' own teachings as weight and shape, or so the Epicureans claim, are inseparable from the atom.'

From this it appears that weight is no longer simply a consequence of size. It is now reckoned to be a character of the atom in its own right, on the same level as, or of the same status as, shape.¹

In this sense, therefore, the writer of the *Placita* is presumably again right to say that Epicurus 'added weight as a third to size and shape'.

(ii)

We can probably tell why there has been this change in the status of weight.

Aristotle's most often repeated and most forceful attack on Democritus lies in his assertion that Democritus and Leucippus failed to state what type of movement belonged to the atoms, or the cause of it.

¹ Shape, size and weight are given by Epicurus himself as the only 'qualities' of the atoms, *Ep. ad Her.* 54.

Met. A 4, 985b19–20 (DK 67A6): παραπλησίως τοῖς ἄλλοις ῥαθύμως ἀφεῖσαν .

'Leucippus and Democritus were no better than the rest of them when it came to movement: where movement is to come from, how it is to be present in the world around us, are questions they lacked the guts to grapple with.'

Met. 6, 1071b31–4 (DK 67A18): οὐ λέγουσιν, οὐδ' <εἰ> ὥδι <ἢ> ὥδι, τὴν αἰτίαν .

'And so some philosophers decide that there is always actuality, as do Leucippus and Plato, in so far as they claim that there is always movement. But why there is movement, and what kind of movement it is, they do not say, nor the reason for its being of one kind or another.'

De caelo iii 2, 300b8–11 (DK 67A16): ἀπεῖρῳ, λεκτέον τίνα κίνησιν καὶ τίς ἢ κατὰ φύσιν αὐτῶν κίνησις .

'That is why Leucippus and Democritus, who claim that the primary particles are always moving in the void and in the endless, should explain what movement they mean, and which movement of the atoms is a natural movement.'

In fact, the Atomists will probably have seen the movement of the atoms sufficiently explained by, or perhaps sufficiently taken for granted as, a concomitant of their eternally pre-existing plurality and diversity, as I shall suggest later. Elsewhere, eternity of movement is expressly stated by Aristotle as the Atomists' cause of movement or perhaps rather as their obviation of any need for a cause.¹

¹ Arist., *Phys.* viii 1, 252a32–b5 (in part DK 68A65), cf. *De gen. anim.* ii 6, 742b17–35 (not in DK): see below pp.364–5.

But the association of movement with plurality and diversity had already lost its vigour by the time that Aristotle was writing, and the ambiguity on which the self-explanatory character of the eternal rests in Democritus' argument, between ἀρχή as first beginning, will have seemed to someone of Epicurus' time impossibly archaic.

The answer therefore which Epicurus provides to Aristotle's criticism is, as we see in this entry of the *Placita*, that the atoms move downwards in the void and that they are impelled to do so by their own weight. Downward movement is intended as an answer to αἰτία.

This explains the change in the status of weight.

1. For Democritus, weight was of secondary importance, dependent upon, and derivative from, size.
2. In Epicurus' system, weight is an answer to the requirement for a cause of movement and it is also a determinant of the kind of movement which the atoms have: it is therefore raised to the level, as it were, of shape, and made a primary character of the atoms.

Conclusion: The 'Addition' of Weight

(i)

If we consider the status of weight in Epicurus, and the relation in his philosophy of weight to movement, then it becomes true to say, of Epicurus, both that he 'added' weight to size and shape as συμβεβηκότα of the atoms, and that without weight his atoms would not move, i.e. they would not fall.

At the same time, it follows that in this entry from Aetius the only implications, with regard to Democritus, need be true implications: that for Democritus the weight of atoms is not equivalent in status to their size and shape, and that weight is not a cause or determinant of the atoms' type of movement, in the sense only that weight does not cause the atoms to fall in the void.

(ii)

Whether the compiler of this entry in the *Placita* intended only these implications is another question.

1. He may have concluded that Democritus had not attributed weight to the atoms at all, as is stated explicitly in the later entry.
2. Alternatively, he may have recognised that Democritus could have attributed weight to the atoms in a sense other than that adopted by Epicurus, or at least subordinately to the categories of size and shape.

Which he did, we cannot tell, and is indeed of comparative little additional significance.¹

§ 3— Cicero

(i)

I turn to the last of the three passages that support, or that may support, the current compromise.

Towards the end of the surviving part of the *De fato* Cicero writes, 20.46 (DK 68A47):

"Declinat", inquit (sc. Epicurus), "atomus". primum cur? aliam enim quandam uim motus habebant (sc. atomi) a

¹ The process which I have suggested may underly the two entries from Aetius can be seen at work in modern writers on the subject. Pillon, in 'L'évolution historique de l'atomisme', 122, groups Simplicius with Cicero and with Aetius (i.e. with 'Plutarch' and Stobaeus) precisely in virtue of the passage where, as Pillon believes, the atoms are said to be 'inertes par nature' (*Phys.* 42.10–11 = DK 68A47, cf. p.224 n.3 above). Goedeckemeyer, *Epikurs Verhältnis* 12–13, rightly protests at this grouping of Simplicius with those who deny, or who appear to deny, the existence of weight for the atoms. Nonetheless Rivaud ignores his warning, *Le problème du devenir* 161, and evidently under the influence of Pillon he includes Simplicius among those who 'affirment catégoriquement que les atomes n'ont pas de poids . . .'. In the accompanying note (p.161 n.369) references are given to the other authors named (Cicero, 'Plutarch', Stobaeus), but not to Simplicius. Thus within the space of less than twenty years (Pillon, 1891; Rivaud, 1906) Simplicius' denial that the atoms have natural movement is construed as a denial that the atoms have weight.

Democrito impulsio, quam plagam ille appellat, a te, Epicure, grauitatis et ponderis.'

The disjunction between *impulsio* or *plaga* in Democritus and *grauitas* et *pondus* in Epicurus repeats more or less the distinction between βάρος in the later of the two passages in Aetius (i 12.6 = DK 68A47), and has been thought to carry the same implication: that for Democritus the atoms were lacking in weight.¹

(ii)

The same implication has been thought to attach, for a different reason, to a passage in the *De natura deorum*, i 26.73:

'quid est in physicis Epicuri non a Democrito? nam etsi quaedam commutauit, ut quod paulo ante de inclinatione atomorum dixi, tamen pleraque dicit eadem, atomos, inane, imagines, infinitatem locorum innumerabilitatemque mundorum, eorum ortus, interitus, omnia fere quibus naturae ratio continetur.'

The absence of weight from the list of Epicurus' 'borrowings' has been taken to imply that weight cannot have been a feature of Democritus' original system.²

(iii)

This second argument may, I think, be dealt with fairly summarily.

The absence of weight is not really, as Lafaist would have us believe, an 'omission surprenante', implying that, for Cicero, weight was not part of Democritus' system. Weight is not on the same level of generality or importance as plural worlds or infinite space.

¹ See above pp. 153–4 and 223 n.1.

² Lafaist, *Philosophie atomistique* 72. There is the same assumption in Liepmann, *Mechanik* 31–3 and 49, cf. p.223 n.1 above, and in Pillon, 'L'évolution historique de l'atomisme' 122 n.2.

A different list, in Simplicius' *Categories*, does in fact include weight along with other properties of the atoms common to Democritus and Epicurus.¹

(iv)

There remains the passage in the *De fato*.

The analysis of this text is complicated by the fact that two earlier passages, in the *De fato* and in the *De natura deorum*, describe the *declinatio* in a way that has been thought to carry the opposite implication: that the atoms of Democritus did have weight, and that, like Epicurus' atoms, they moved downwards in the void.

The intention of these earlier passages needs to be clarified, if we are to gain a clear view of the possible implication in the passage that I first quoted of the disjunction between *impulsio* or *plaga* in Democritus and *grauitas et pondus* in Epicurus.²

The 'Declinatio'

(i)

The ideas from the end of the *De fato* are given more fully in, and indeed seem to be repeated from, an earlier passage, where Cicero writes, 10.22–3:

'sed Epicurus declinatione atomi uitari necessitatem fati putat. itaque tertius quidam motus oritur extra pondus et

¹ *Cat.* 216.31–217.5. Weight is here joined with shape, solidity, corporeality, surfaces, size and movement, as opposed to colour, taste, life, intelligence, nature and rationality, as things that on the atomic theory are generated only from the conjunction of elements.

I have not given more prominence to this piece of evidence, partly because the double attribution, to Democritus and to Epicurus, would make it difficult to argue specifically for the beliefs of Democritus, and also because the context is in any case a highly intellectualised one, in which it could well be argued that either thinker is used mainly as a peg on which to hang a view opposed to Simplicius' own.

² The *De fato* was planned as a supplement to the *De natura deorum* and the *De divinatione*; these three works were subsequent to the *De finibus*, from which I quote later: see *De div.* ii 1–3.

plagam, cum declinat atomus interuallo minimo . . . nam qui potest pelli alia (sc. atomus) ab alia, si grauitate feruntur ad perpendicularum corpora indiuidua rectis lineis, ut Epicuro placet? . . .

'hanc Epicurus rationem (sc. declinationem) induxit . . . ueritus . . . ne, si semper atomus grauitate ferretur naturali et necessaria, nihil liberum nobis esset . . . id Democritus, auctor atomorum, accipere maluit, necessitate omnia fieri, quam a corporibus indiuiduis naturalis motus auellere.'

In this passage, the plural expression, *naturalis motus*, has been taken to cover the movements indicated by *pondus et plagam* jointly, and so as ascribing to Democritus primary movement downwards, as determined by weight.

On this interpretation, the point of the passage is that:

'Democritus was unwilling to sacrifice to the *declinatio* the "natural movements" of the atoms, as caused by weight and by impact. He preferred to leave the atoms to be governed by necessity, and to fall endlessly downwards as a natural and a necessary consequence of their weight.'¹

(ii)

There is a comparable passage earlier in the *De natura deorum*, i 25.69:

'Epicurus cum uideret, si atomi ferrentur in locum inferiorem suo pte pondere, nihil fore in nostra potestate, quod esset eorum motus certus et necessarius, inuenit quomodo necessitatem effugeret, quod uidelicet Democritum fugerat: ait atomum, cum pondere et grauitate directo deorsus feratur, declinare paululum.'

¹ This is Brieger's argument, *Urbewegung* 9. Since Brieger also believes that in the later passage, 20.46, Cicero intends to deny that Democritus' atoms have weight, he concludes that Cicero's evidence is inconsistent: 'Er zwingt uns, den Angaben Ciceros über Demokrit, ja über die Atomiker überhaupt jede auch noch so geringe Autorität abzusprechen'.

This passage has been taken in a similar way, as implying that Democritus, no less than Epicurus, needed a *declinatio*, so to speak, to prevent his atoms from falling endlessly in the void.¹

On this reading of the passage, Democritus is stuck, as it were, at the point that Epicurus takes off from. Democritus' atoms, like those of Epicurus, are carried downwards by their weight. The difference is that the 'escape' that Epicurus found from necessity had 'escaped' Democritus—I take it that the play on words is deliberate.

(iii)

In either case, the implication that I have outlined is possible, it seems to me, if the passages are taken strictly by themselves, though in either case we are left to wonder how Cicero thought that Democritus' atoms ever joined together to form a cosmos if they started off in the same condition as Epicurus' atoms—falling straight downwards in the void—with no *declinatio* to release them.

But even if we answer that question by some consideration extraneous to the context—differences of speed, for example—it still does not follow that either implication is at all a necessary one.

1. In the *De natura deorum*, the connection implied between Epicurus and Democritus by the rather frivolous play on words—the 'escape' from necessity that 'escaped' Democritus—is far too tenuous for the only implication to be that the situation that Democritus was left in was precisely the situation that Epicurus escaped from.

2. In the earlier passage of the *De fato*, the plural expression, *naturalis motus*, could as well cover *pondus* or *plagam* singly or together, as types of movement which, whether singly or jointly, are at least regular expressions of the atoms' behaviour, as opposed to what are later called the *commenticiae declinationes* (20.48): the unnatural and arbitrary irruption of a motive force which so roused the scorn of Cicero, or his source.

¹ This claim is made (for different purposes) both by Brieger, *Urbewegung* 8–9 and 'Urbewegung' 587, and by Zeller, ZN 1090 n.2.

In both passages, Cicero's point is essentially that the *declinatio* has to be invoked in order to escape from the simple downward movement of atoms in the void. In making this point, Cicero simply does not let it be seen clearly—in the immediate context of either passage—whether he thinks that the background to this innovation, the downward movement of atoms in the void, was also an innovation by Epicurus, or a feature that Epicurus had taken over from Democritus.

(iv)

This ambiguity is, I believe, resolved by a slight, but telling, phrase in the only other passage where Cicero deals at any length with the *declinatio* and with differences between Epicurus and Democritus on the nature of the atoms and their movements in the void.

In the first book of the *De finibus bonorum et malorum* Cicero writes of Epicurus and Democritus, 6.18–19:

'... de materia disseruerunt, uim et causam efficiendi reliquerunt. sed hoc commune uitium: illae Epicuri propriae ruinae. censet enim eadem illa indiuidua et solida corpora ferri deorsum suo pondere ad lineam: hunc naturalem esse omnium corporum motum. deinde ibidem homo acutus, cum illud occurreret, si omnia deorsum e regione ferrentur et, ut dixi, ad lineam, nunquam fore ut atomus altera alteram posset attingere, itaque (N.B. 'insolens oratio', Madvig) attulit rem commenticiam: declinare dixit atomum perpaulum . . . quae cum res tota ficta sit pueriliter, tum ne efficit <quidem> quod uult, nam et ipsa declinatio ad libidinem fingitur . . . et illum motum naturalem omnium ponderum, ut ipse constituit, e regione inferiorem locum petentium, sine causa eripuit atomis.'

It has been acutely observed, by Hirzel, that in the final sentence the little phrase, *ut ipse constituit*, betrays sufficiently clearly that Cicero, or his source, recognised the downward movement of the atoms as an innovation by Epicurus.¹

¹ Rudolf Hirzel, *Untersuchungen zu Cicero's philosophischen Schriften*, Theil ii 'De finibus, De officiis' Abtheilung 2 (Leipzig, 1882) 660 n.2.

In the light of this phrase, the remainder of the passage I have quoted, and the pages immediately preceding and following, can be read without ambiguity. In Democritus' world, the atoms move *nullo a principio* in space that has *nec summum nec infimum nec medium nec ultimum nec extremum* (i 6.17), on both counts therefore distinct from the 'natural' movement of Epicurus' atoms, *illum motum naturalem omnium ponderum . . . e regione inferiorem locum petentium*. The 'errors peculiar to Epicurus', *Epicuri propriae ruinae*, will include both the fall of atoms and the swerve. It is only after the *declinatio* that the two systems will coincide, in the difficulty of the *turbulenta concursio* of atoms, *in quo etiam Democritus haeret* (i 6.20).¹

¹ Professor Guthrie, *History* ii 402, takes *Epicuri propriae ruinae* as sufficient indication that the fall of atoms is peculiar to Epicurus. But as Hürzel had noted, taken in itself that phrase could refer exclusively to the *declinatio*. It is only the later expression which frees our reading of Cicero's passage from ambiguity.

Bailey, *Greek Atomists* 130, takes the beginning of the passage as proof that Democritus' atoms are moved by weight, i 6.17 (DK 68A56): 'ille (sc. Democritus) atomos quas appellat, id est corpora indiuidua propter soliditatem, censet in infinito inani . . . ita ferri' etc. But here *propter soliditatem* will presumably represent not ἀδι-αίρετα used as a name or synonym for the atoms see Simpl. *De caelo* 242.19 (DK 67A14), Arist. *De gen. et corr.* i 8, 326a10 (DK 68A60, above p.41). Hardness or solidity is given as a reason for the atoms' indivisibility, for both Democritus and Epicurus, by Dionysius, *ap. Eus. Praep. evang.* xiv 23.3 (DK 68A43), and for Democritus alone by Simplicius (?), *De anima* 62.2–4 (not in DK).

It is true there is a certain discrepancy in the sources on this point. Galen makes Epicurus' atoms 'unbreakable because of their hardness', and Leucippus' atoms 'indivisible because of their smallness', *De elementis secundum Hippocratem* i 2 = i 418–19 Kühn (DK 68A49), while Simplicius makes Leucippus' and Democritus' elements 'atomic because of their smallness and solidity', *De caelo* 609.17–19. A number of other passages bear on the question (notably Simplicius, *Phys.* 81.34–82.6, cf. pp.273–6 and 278–9 below, *Phys.* 925.13–22 = DK 67A13, cf. pp.270–2 below, Diogenes ix 44 = DK 68A1). Without wishing to demonstrate the point, I would note only that I take both smallness and hardness or solidity (the two connotations attach to στερεός, στερεότης etc., cf. LSJ s.v.) to have been originally the reasons for the atoms' impenetrability and indivisibility, and that Epicurus abandoned the argument from size, whether in connection with his notion that atoms have 'parts' (above pp.213–14), or perhaps as a concession to Aristotle's criticism that small atoms have no stronger claim to being indivisible than larger ones (*De gen. et corr.* i 8, 326a24–9, not in DK).

(v)

It is possible that Cicero is inconsistent, inconsistent either in his own conception of ancient Atomism, or more simply inconsistent in his use of sources. It is possible therefore that the implication which Hirzel has noted from the *De finibus* cannot properly be carried over into our interpretation of the passages from the *De fato* and the *De natura deorum*.

I am reluctant myself to think that this is so. I have called Cicero's play on words frivolous. But I do not think that Cicero was foolish. It seems to me likely therefore that the implication which Hirzel has noted in the *De finibus* excludes the assumption that in either of the other two treatises Cicero deliberately attributes downward movement in the void to the atoms of Democritus.

1. In the *De natura deorum*, the 'escape' that Epicurus found from necessity 'escaped' Democritus. But the necessity to which Democritus remained bound was not, therefore, the 'necessity' by which atoms in Epicurus' system were carried inexorably downwards by their weight.
2. Similarly, in the earlier of the two passages from the *De fato*, the 'natural movements' which Democritus was unwilling to 'snatch' from the atoms will have been only movements caused by the collision and recoil of atoms; they will not have included the 'fall' of atoms in the void.

On this construction, the point to appreciate—the solution to the puzzle—is that Cicero's hostility to the *declinatio* has caused a radical re-alignment in the notion of what is 'natural'.

1. For Aristotle, 'natural' movement is opposed to movement that is the result of force or collision.
2. For Cicero, the arbitrary character of the *declinatio* is alone unnatural, and movement that is independent of the *declinatio* is therefore seen as 'natural' and 'necessary', including *both* the 'fall' of atoms *and* movements that are the result of collision.

This leads to the paradox that the 'natural movements' of the *De fato*, the movements caused by collision and recoil which Democ-

ritus was unwilling to 'snatch' from the atoms, are precisely the movements which in Aristotle's philosophy are *opposed* to the 'natural' movement of the elements. For Cicero, movements 'by force' are 'natural' movements, because they do at least exclude the *declinatio*.

Weight and Movement

I return therefore to the passage from later in the *De fato* which I quoted at the beginning of this section.

The similarity between the passages that I have quoted hitherto, read in their entirety, and the fact that Cicero nowhere else treats of the same subjects with anything like the same circumspection or discrimination, allow us, I think, without undue scrupulosity, to continue to read the pages from later in the *De fato* in the light of the distinction that I have drawn from the *De finibus*, and that I have applied already to the passage earlier in the *De fato* and to the similar passage in the *De natura deorum*.

If we do so, then we find in Cicero essentially the same network of ideas that I have argued we have in the two entries in the *Placita*.

1. Weight, *grauitas et pondus*, is attributed to Epicurus exclusively, as also is the fall of atoms.
2. Democritus' atoms are moved by *impulsio*, *quam plagam ille appellat*, precisely the term which is recorded in Simplicius, and are not envisaged as moving downwards.

As in the case of the earlier entry in Aetius we cannot tell for certain whether this is intended to imply that Democritus' atoms were without weight.

There is possibly less reason to suppose that it should do so, since Cicero is innocent of the statement which we find in the later entry, that the atoms 'have no weight'.

On the other hand, the regular association in the other passages I have quoted of *pondus* or *grauitas* with movement downwards, which is specifically stated in the *De finibus* to have been instituted by Epicurus, perhaps makes it more likely that Democritus' atoms are not thought of as having weight.

But equally this regular association of *pondus* or *grauitas* with

movement downwards obviously leaves little room for 'weight' that would *not* be thought of as movement downwards.

The two points therefore cancel each other out, as it were. The more likely it is that Cicero, or his source, will have supposed that Democritus' atoms were without weight, the more arguable, and the more obvious, will it be that this was nothing more than a concomitant of the atoms' freedom from downward movement.¹

Conclusion

Adolphe Franck in his *Dictionnaire des sciences philosophiques* claims that, against the testimony of Aristotle and of Theophrastus, there are:

'mille témoignages contraires, qui nous montrent la pesanteur des atomes comme une innovation introduite par Épicure dans le système de son maître'.²

On a more sober calculation, the 'mille témoignages' shrink to only one: a single entry in Aetius.³

¹ Cicero's evidence has often been misunderstood. Perhaps the most extreme example is Bailey. (1) As I have noted, Bailey misunderstands, *Greek Atomists* 130, the description of the atoms as *individua propter soliditatem*, at the opening of the passage from the *De finibus*, i 6.17 (DK 68A56); Bailey here takes Cicero to be describing a movement that is the result of weight, and therefore to be saying the same as Theophrastus, in a passage (*De sens.* 71), which he has also misunderstood, see pp.137–42 and p.224 n.3 above. (2) This error leads Bailey to take the passage from the *De fato*, 20.46 (DK 68A47), as providing an 'identification of the Democritean "blow" with Epicurus' notion of weight' (*Greek Atomists* 134), whereas in fact it is clear that Cicero intends to distinguish at this point between the theories of Democritus and Epicurus. (3) However, Bailey also believes that Democritus' atoms do not move downwards in the void; he therefore concludes (pp.134–5) that 'Cicero's statement is almost certainly founded on the false conception that Democritus assigned weight as the cause of motion'. (4) But although Bailey thinks that Cicero is here in error, he nonetheless seeks to use his passage (p.135) as a true description of the 'derivative motions', which are common to Democritus and Epicurus, and which are 'logically subsequent' to the original motion of the atoms. But this reading of the text is plainly at odds with Cicero's intention, in the *De fato* as in the *De finibus*, to start by describing the movement of Epicurus' atoms *prior* to their release by the *declinatio*.

² Article 'Démocrite' in *Dictionnaire des sciences philosophiques* ii (Paris, 1844) 32 = 2nd edn (Paris, 1875) 356.

³ Franck is not alone. Mabillean writes, *Histoire de la philosophie atomistique* 195: 'On peut dire que les opinions se partagent en deux camps: Aristote affirme que les atomes de Démocrite sont pesants, presque tous les autres témoignages tendent à établir le contraire'. He concludes: 'Le nombre, ici, balance l'autorité . . . '.

**PART THREE—
THE CONCILIATION OF THE EVIDENCE**

**Chapter Nine—
The Nature and Distribution of the Evidence:
Primary Evidence**

**§ 1—
Sources for the History of Early Philosophy**

The perversities of chance and of human neglect have left what are now almost certainly ineradicable scars on our potential knowledge of the thought and experience of the ancient world. By a singular good fortune the three most original, most influential, and the most difficult pagan philosophers, Plato, Aristotle and Plotinus, have survived to us with a large part or even with the whole of the works which they themselves composed. Otherwise, with the partial exception of Epicurus, every other major philosophical figure of earlier pagan antiquity is known to us only in fragments and at second hand.

The loss of original material is especially crucial for the century or so before Plato. Not only was this a period of intense philosophical activity, of the most varied and the most fascinating kind: it was also a time sufficiently primitive or archaic, or at least, if those terms are too crudely evaluative, sufficiently different from our own to make it particularly difficult to recover from any other than an exceptionally sensitive source the true intent of a thinker of this period: and our sources are not exceptionally sensitive, and are often not sensitive at all.

For this early period, we rely on four main blocks of material: (1) the frequent allusions to and analyses of earlier theories scattered throughout the works of Aristotle, (2) the extensive transcripts from Parmenides, Anaxagoras, Empedocles and Diogenes recorded by Simplicius, in his commentaries on Aristotle, (3) direct fragments from Theophrastus' accounts of the early philosophers, and especially the long fragment on the nature of the faculty of sense and of the objects of sense, and finally (4) later digests and redactions of Theophrastus' work, principally those contained in the two surviving versions of Aetius.

There remains an enormous number of other allusions to the early philosophers scattered through almost the whole of subse-

quent ancient literature. These vary greatly in value: but, with the possible exception of Plutarch, all of these other sources taken together hardly exceed in value any one of the four major sources of our knowledge, taken alone.

From this, it is at once apparent how much we owe, directly and indirectly, to Aristotle: directly, because of the time which he himself devotes to the discussion and refutation of Presocratic ideas, and indirectly because Simplicius and Theophrastus are thereby led, in their different ways, to their own interest in early philosophy. If Aristotle had been as evasive in his attitude to the Presocratics as Plato in fact was, our knowledge of Presocratic philosophy would have been immeasurably darkened.

I have added these very general remarks at the beginning of this section of my argument, because in reviewing any long-standing problem in the history of early philosophy I think one has the duty to consider, in general terms, what chances of success are offered by the evidence, so as to try to make sure that one is not adding wantonly to what must seem at times, to any conscientious worker in the field, the wearisome mountain of modern scholarship on the Presocratics, some of it remarkable for its learning and acuity, but much of it loosely argued and inconclusive, even when it is not downright unscholarly or perverse.

As it is, from the point of view of the spread of evidence, the present problem should prove no more intractable than many another problem in the history of early philosophy, for although all the evidence is second-hand there is at least some explicit information from all four major sources: Aristotle, Theophrastus, Simplicius (although not in this instance as a source of direct quotation) and Aetius, with one or two other authors providing useful if tangential information.

Why then has the solution of the problem, if it has not been found already, proved so elusive?

To such a question there is no single answer. But if I may generalise, then the answer is probably that a series of local difficulties in the main texts has conspired with a more general conceptual difficulty, the possible difference between Platonic or Aristotelean and pre-Platonic conceptions of heavy and light, so as to make any single synopsis of the evidence more than usually difficult of attainment.

If in fact we stand back to consider the distribution and rela-

tion of the evidence as a whole, taking now for granted the more particular questions of exegesis and interpretation which have been handled in the preceding sections, then the form of the question that we need to ask determines, almost of itself, the answer that we should give to it.

Is one entry in Aetius able to overrule a number of passages in Simplicius, and to effect a major qualification of evidence provided by Theophrastus in his *De sensibus* and in two places by Aristotle?

The answer, in terms of general doxographical probability, is that it may be able to do so, but that it is unlikely.

It will be less unlikely, only if the evidence in Aristotle and in Theophrastus encourages, or at least leaves room for, the qualification required by Aetius.

More specifically, the question which we need to consider is therefore:

Is there any indication that when Aristotle and Theophrastus write of the atoms' possessing weight they are thinking only of atoms within a cosmos, or at least within the beginnings of a cosmos, so that Aetius' denial of weight to the atoms can be applied to atoms before or outside the formation of a cosmos?

To this question I address myself in the following two sections of this chapter.

§ 2—

Theophrastus

At this point, I consider the evidence in Theophrastus before that of Aristotle, since from the present point of view Theophrastus is perhaps the more useful witness of the two. For Theophrastus does record Democritus' theory of weight for its own sake, and as a whole. On both points therefore he differs from Aristotle, whose allusion to the theory in the *De generatione et corruptione* is part of a more general argument, and whose account of Democritus' theory in the *De caelo* is tied closely to his critique of Plato.

(i)

It is true, there is the fear that since Theophrastus' criticism of earlier theories is heavily indebted to Aristotle, so too his account of the substance of Presocratic theories may also be coloured by Aristoteleanism.

In fact, my own impression, for what it is worth, is that this possibility is quite largely counterbalanced by the deliberate division which Theophrastus makes between précis and criticism. For in the précis which he gives, Theophrastus does attempt to write, as we should say, objectively. Thus in the introduction to the second part of his *De sensibus*, on the nature of the objects of sense, he writes, in relation to Plato and Democritus, cap. 60 (DK 68A135):

εἰπόντες τὴν δὲ ἄληθιν ἔφοδον ἑκατέρου.

'It is not our immediate concern to decide on which side the truth lies. Our present purpose is to try to convey to the reader how far each thinker went in tackling the problem, and the nature of his conclusions, after first sketching out the general line of approach that each of the two philosophers adopted.'

In this circumstance, it seems to me, Aristotle's influence on the substantive elements of Theophrastus' history is likely to be apparent, if at all, not so much in what is included, as in what is omitted.

A notable—and hitherto unrecognised—example of such omission I shall attempt to demonstrate in a parallel study to this, on the nature of early theories of perception and intelligence, with particular reference to Empedocles' theory of intelligent perception by blood. I shall there attempt to show that under the influence of Aristotle Theophrastus has failed to specify the rôle of differences of temperature in his account of Empedocles' theory of variations in perception and intelligence, notably at *De sensibus* 10–11 (DK 31A86).¹

¹This work is due to appear in *Philosophia Antiqua*, and is provisionally entitled *Théories présocratiques de la perception et de l'intelligence, étudiées d'après la tradition biographique d'Empédocle*. See also pp.342–3 below.

But, it may be objected, this is precisely the phenomenon which the modern interpretation of Democritus' theory of weight would have us fear in the present instance: the omission of a qualification, restricting the theory of atomic weight to atoms that are caught within the formation of a cosmos.

(ii)

In fact, it seems to me that several considerations tell against this, of which the simplest and perhaps the clearest is afforded by the stipulation which Theophrastus attaches to his initial definition of weight in terms of size, cap. 61: εἰ γὰρ διακριθεῖη καθ' ἕν ἕκαστον

I have already noted that the mention of ἕκαστον is here an atom.¹ If then each atom is to be 'taken separately on its own', it will fairly clearly be irrelevant whether we have 'taken it', so to speak, from a cosmic vortex or from a precosmic void.

The stipulation required by Burnet's reconstruction of the theory would be in effect the opposite of this:

'If the atoms are considered in relation one to another, when they have been drawn into a vortex'²

(iii)

More generally, the scrupulosity of Theophrastus' account is shown by the sentences which conclude his initial statement of

¹ Cf. ch.IV § 1, esp. p. 121 above.

² I have already noted the translation of Theophrastus' stipulation as 'if we were to divide each substance into its <atomic> units' (Stratton, 121) or as 'if any object is decomposed into its parts' (Sambursky, *The physical world of the Greeks* 120). In this translation, Theophrastus' stipulation would introduce the atoms only indirectly, as it were. But this would not really weaken my present argument. For even in this form Theophrastus' stipulation would not coincide with the stipulation required by Burnet's interpretation. In Stratton's translation, Theophrastus specifies the separation of a compound body into its individual atoms, which are then the subject of the definition. On Burnet's interpretation, Theophrastus should specify the atoms as having weight only when they are drawn into a cosmic vortex, and therefore only when they are already being brought together as compound bodies.

Democritus' theory of weight, cap. 61–2: κοῦφον εἶναι φησιν ἀπλῶς τὸ λεπτόν.¹

The more precise relevance of this remark I shall try to uncover later, in considering the general Presocratic background to Democritus' ideas.² What is significant at the moment, is simply the fact that Theophrastus was alive to, even, one might venture to think, on the look out for, potential discrepancies in Democritus' theory, and that for this purpose he was able, and willing, to compare different parts of Democritus' writings.

For the statement in Aetius, that the atoms λεπτόν. If therefore there had been anything approximating to Aetius' statement in Democritus' own writings, then we may well expect that, in this circumstance, it would not have escaped Theophrastus' attention.³

(iv)

It might perhaps be argued, against this, that Theophrastus' horizons are limited to the discussion of *sensibilia*, and that the nature, or the behaviour, of atoms in the void, before the formation of a cosmos, necessarily falls outside this purview.⁴

But this argument proves to be two-edged.

Theophrastus' primary criticism of Democritus, and of Plato, is that they confuse principle and practice.

1. Plato claimed to treat the objects of sense as existent in their own right, but in fact he reduced them to alterations of the faculty of sense.

¹ For my paraphrase see above p. 131.

² Pp.372–8 below

³ The two specifications ἐν ἄλλοις Paul Tannery first translated as 'pour certains corps' and 'pour d'autres', *Pour l'histoire de la science hellène* (Paris, 1887) 359. But Diès rightly corrected this in the second edition, (Paris, 1930) 369, to 'en certains endroits' and 'en d'autres'.

⁴ Dyroff, *Demokritstudien* 32: 'Theophrastos lässt klar erkennen, dass dem Demokritos "Schwere und Leichtigkeit" Sinnesqualitäten waren, nicht Eigenschaften der ursprünglichen Atome'. Cf. pp.356–9 below.

2. Democritus claimed in principle to reduce the objects of sense to affections of the faculty of sense, but in practice he defined them as entities existing independently.¹

From this preliminary orientation, Theophrastus argues that heavy and light in particular, and hard and soft, are in effect made φύσεις in their own right, as opposed especially to temperature, which, on Democritus' theory, is no more than an affection of the faculty of sense when it is subjected to a process of alteration. The repetition of this criticism demonstrates its importance for Theophrastus.²

Thus in the case of temperature—or colour or flavour—it would be right to claim that the effect, and indeed the point, of Democritus' theory is that 'hot'—or 'red' or 'sweet'—comes to exist only within the conditions of a cosmos, or indeed, more narrowly, comes to 'exist' only within the experience of a sensible percipient.

But Theophrastus' distinction shows that we cannot argue from the formulation of Democritus' theory in the case of temperature to an equivalent formulation in the case of weight. For according to Theophrastus' categorisation weight is a 'nature' in its own right, and is not simply the expression of an alteration of the faculty of sense.

(v)

Heaviness, it might still be argued, is paired with light, and the two are grouped with hard and soft: all of which appear only as characters of compound bodies, and can therefore appear only within a cosmos.

To pursue this issue fully would entail consideration of the whole of Democritus' theory of sensible perception.

Briefly, it is true that the question may not be as simple for hard as for heavy. For in the case of hardness we can distinguish what one might perhaps call an ontological condition, the condition of the atoms represented as τὸ πυκνόν, and the effect of this condi-

¹ *De sens.* 60–1 (DK 68A135).

² *De sens.* 63, 68, 71 (DK 68A135).

tion upon the faculty of sense. This latter condition alone, Democritus might claim is what he means by hardness.

The question is again different in the case of lightness. For while Theophrastus begins by saying that both heavy and light are defined by size, he then goes on to give an alternative definition of lightness as determined not in terms of size simply, but of void.

Lightness in this second sense, lightness as determined by void, is necessarily restricted in its application to the formation of compound bodies, and therefore, we may perhaps allow, to conditions within the formation of a cosmos.¹

However, neither qualification can be applied to the definition of heavy and light in terms of size. Heaviness is attached not to a certain distribution of atoms, nor to a certain proportion of solid and void, but quite simply to the size of individual atoms. *Prima facie* therefore there is no reason for heaviness to be restricted to the interaction between atoms and the faculty of sense or to appearances within a cosmos.

‘Σταθμός’

The only point which in fact, it seems to me, could conceivably tell in favour of what I have called the 'current compromise' is that the word which Theophrastus has employed in his account of the individual atom, the term **σταθμός**, is drawn from the use of a pair of scales, and so (it might be argued) can apply only to movement in a specific direction, and therefore only to movement within a cosmos.

(i)

At first glance, there might conceivably appear to be some substance in this argument. But a moment's reflection shows it to be meagre in the extreme.

¹ I do not find any discussion of whether in fact transitory compound bodies—other perhaps than the bodies of the gods—can be formed outside a cosmos.

There are three expressions which Theophrastus could have used for the notion of weight:

1. βαρὺ καὶ κοῦφον
2. ῥοπή
3. Σταθμός

1. Theophrastus does employ, in his opening sentence (cap. 61), the composite expression, βαρὺ καὶ κοῦφον, of which neither term, at least in its immediate signification, requires the notion of movement.

2. He does not employ the term ῥοπή, which would necessarily entail the notion of weight expressed as movement.

3. Σταθμός is employed in the account of the individual atom, and is intermediate in its connotation.

The material reference is to the movement, or balance, of a pair of scales. But the term is used so generally, throughout Greek literature, that especially when it is used adverbially it has clearly come to retain only a notional relation to any actual act of weighing.

(ii)

If we consider the matter further, even such residual or notional connotation as at first sight there may be of the idea of movement seems to me effectively precluded by the form in which Theophrastus has chosen to cast his statement about weight.

Theophrastus' purpose is to give a complete sketch of the atomic theory of weight. From the start therefore he has one eye, so to speak, on the definition of lightness in terms of void. This he expresses in terms of the comparison of one body with another, and more specifically in terms of a plurality of 'mixed' bodies:

μὴν ἄλλ' ἐν γε τοῖς μικτοῖς.

A very natural, if strictly unnecessary, sense of antithesis leads Theophrastus to think of the alternative definition, of weight in terms of size, as applying to a single atom: εἰ γὰρ διακριθεῖη καθ' ἐν ἑκαστον.

This antithesis leads Theophrastus to cast his first definition of weight in a highly artificial form: 'if one <atom> were to be taken on its own . . .'. No one in fact, in any literal sense, is going to take

hold of a single atom and measure it or weigh it: hence the fully 'unreal' form of conditional sentence, with διακριθῇ in the protasis.

This degree of artificiality, or perhaps one should say more kindly this degree of sophistication, seems to me to preclude there being any literal connotation in the use of σταθμός. That term, I would suggest, is used in this context as a conventional expression for 'weight', with only the most notional and residual attachment to any act of 'weighing', and therefore without any necessary connotation at all that the weight of an individual atom would necessarily be expressed in terms of its movement in a specific direction, and therefore in terms of its behaviour within a cosmos.

§ 3—

Aristotle

'De Generatione et Corruptione'

In the *De generatione et corruptione* Aristotle is less scrupulous than Theophrastus, in that he treats heat, no less than weight, as a characteristic of an atom in its own right, and not simply as a product of the interaction between a certain shape or size of atom and a sensible percipient.

This may be simply because Aristotle wants to make a quick breach in Democritus' theory of the impassibility of atoms. It may also be that the number of times Democritus referred to the theory left occasions when the expression of the theory was vulnerable to an 'objectivist' interpretation:

... καὶ ταῦτα πολλάκις λέγοντα, διότι τοῦ θερμοῦ τὸ σχῆμα σφαιροειδές (Theophr., *De sens.* 68 = DK 68A135).¹

It is perhaps a straw in the wind that the mention of weight is different on two counts from what is said of heat.

1. Heat, i 8, 326a3–5: περιφερεῖ σχήματι τὸ θερμόν .

2. Weight, 326a9–10: Δημόκριτος ἕκαστον τῶν ἀδιαιρέτων .

¹Zeller's emendation, ZN 1076 n.1, of χυλοῦ (Schneider) is certain, despite its omission by Diels in his text in *Doxographi graeci*: cf. Brieger, *Urbewegung* 6 n.1.

The critical context of both assertions is similar, very roughly:

1. 'The atoms are supposed to be inactive and impassible, and yet they do have heat.'
2. 'It would be odd if the atoms were characterised by an opposition of temperature but lacked other oppositions—and yet each atom is more heavy <or less so>.'

But there the similarity ends.

1. The point about heat is itself enveloped in criticism—'it is odd to make the atoms have only heat'—and the expression is loose—'to hand out heat to a certain shape'.
2. The point about weight is expressed free from immediate criticism, and the attribution is given directly: 'Democritus says that . . . '.

In this latter instance therefore form and immediate context leave no obvious opening for any qualification of the idea attributed to Democritus.

'De Caelo'

(i)

The state of affairs in the *De caelo* is more complex than that in the *De generatione et corruptione*.

In an earlier chapter I argued that the exposition of the atomic theory in terms of bodies differing in volume was the result of Aristotle's own presentation and critique of the theory.¹ An equally striking feature in Aristotle's treatment of the atomic theory is the conception of the atoms as moving consistently downwards, and in that sense as approximating to the possession of absolute heaviness.

This conception is of course no surprise for Zeller, for whom it is indeed one of the main indications that the atoms did in fact fall in the void, for Democritus as for Epicurus.

However, Zeller was—or should have been—no less embar-

¹Ch.III §§ 2–3, pp.100–14.

passed by Aristotle's assertion, in the *De caelo* as elsewhere, that the kind of movement belonging to the atoms was never specified.

Brieger and Leipmann, I am reasonably sure, were right to take the second set of passages, those namely where Aristotle denies that the nature of the atoms' movement was specified, as doxographically prior. For in these passages we have the 'tag' of personalised assertion, or what is almost as effective from a doxographical point of view, the statement that 'they failed to say, but should have done'.¹

The credentials of the opposing statement, that the atoms have a single movement, by which Aristotle means primarily movement in a single direction, are entirely different. The atoms have a single nature, and therefore 'it is necessary' for them to have all the same movement.²

There is a further point. We can actually see the evolution, within the *De caelo*, of Aristotle's assumption, from the notion that the atoms must have a single movement, to the notion that this single movement must be movement downwards.

1. In the first book, the movement that the atoms 'must' have is *either up or down*—which it is, does not matter, provided that they have only one.

2. In the criticism of the fourth book, the assumption is conveniently that in fact the atoms would have downward movement only, and where Aristotle wishes to make play with the notion of upward movement he introduces void as representative, or as constitutive, of an element that would be light absolutely.³

¹*Met. A* 4, 985b19–20 (DK 67A6), note λεκτέον. These three passages have been quoted and paraphrased above, p.237. References to the dispute between Zeller on the one hand and Brieger and Leipmann may be obtained from the Bibliography: see also pp.350–9 below. On the question of movement especially, see Leipmann, *Mechanik* 33–8.

²*De caelo* i 7, 275b29–276a2: ἀναγκάϊον b31 and a2. The passage is quoted in full and paraphrased pp.11–12 above.

³*De caelo* i 7, 275b29–276a6; iv 2, 309a33–b4 et alibi; cf. pp.11–19 above. I write of 'evolution', which will be true of course only on the traditional ordering of the books of the *De caelo*. I should perhaps write only of inconsistency. But even inconsistency is a good sign that Aristotle is inventing.

(ii)

This *second* conception of the atomic theory of weight leaves itself open to the criticisms which I have quoted earlier, and which are all essentially reducible to the formulation which Aristotle offers at the end of the penultimate chapter of the fourth book. The argument here is that if air and water are both composed of a single material principle, or if they both contained two constituents, one with absolute heaviness and the other with absolute lightness, then there will be a large quantity of water which will contain more of the light element than is contained in a small quantity of air, and a large quantity of air which will contain more of the heavy constituent than is contained in a small quantity of water, so that air, in a certain quantity, will be heavier than water, and water, in a certain quantity, will be lighter than air.¹

The point of this criticism is that Aristotle will allow no escape from the conclusion that each of the four elements must have its own natural place, and that their observable behaviour cannot therefore be reduced either to one or to two simple constituents, for it can always be argued that this will lead to a disturbance of the natural movements and stratification of the elements.

The theory therefore which Aristotle criticises at length in book four of the *De caelo* is admittedly, in large measure, a construction of his own. Granted that the atoms have a single nature, they must (on Aristotelean principles) have movement all in the same direction, which soon comes to be envisaged as movement downwards: how far then, if at all, can the atoms be used to explain the movement of the four elements towards their natural stratification which is an observable, and for Aristotle an indisputable, feature of the cosmos?

(iii)

I conclude therefore that in Aristotle's presentation and critique of the atomic theory there are two persistent features which we can reasonably infer have intruded themselves into the original form of the theory.

¹ iv 5, 313a 10–13: the detail of this formulation is analysed in my third and fourth essays.

1. The definition of lightness as dependent upon atoms and void is presented in terms of bodies which differ in volume.
2. The definition of weight as related to size is presented as requiring the atoms to move consistently downwards.

In cutting away so generous a pound of flesh, how much of the atomic theory can we hope will have survived? Is there any hope that in peeling away the accretions of Aristotelean assumption and terminology there will be left any residual core of possible or probable historical truth?

As before, I think that if we isolate accurately the distortions which Aristotle has introduced into his presentation of the theory we can infer, with reasonable certainty, in this instance at least, what there is of the original theory that does not derive from Aristotle's presentation of it.

As I noted earlier, on the question of the definition of lightness in terms of void, there is sufficient contradiction within Aristotle's own presentation and critique of the theory for us to be able to infer, with reasonable certainty, that the Atomists' own formulation of their theory either left the comparison of volumes out of account or alternatively was presented in terms of bodies equal in volume, where therefore the comparison of void with void is a sufficient indication of weight.¹

The same principle, I believe, can be applied if we consider Aristotle's assertion that the weight of atoms is dependent upon their size, in the light of Aristotle's treatment of the atoms as needing to move downwards.

(iv)

Thus Bailey argues that Aristotle's remarks about atomic weight in the *De caelo* are orientated exclusively towards the behaviour of atoms within a cosmos, with the conclusion, therefore, that Aristotle's analysis leaves the way open for a denial of any precosmic or extra-cosmic weight to the atoms, as on Burnet's thesis.

¹ Cf. pp.105 and 111–14 above.

'Throughout the discussion', in the *De caelo*, Bailey writes, 'Aristotle is thinking of weight in a formed cosmos and regards "heaviness" as a tendency "downwards", that is *towards the centre*, and lightness as a tendency upwards, that is, *towards the outside*.'¹

Now it is true, as we have seen, that in his critique of the Atomists Aristotle does require the reader, or the listener, to envisage how the atoms would be supposed to behave within a cosmos. And it is true that in so doing Aristotle is not describing a theory of atomic weight which Democritus himself expressed as applying to the behaviour of atoms within a cosmos.

For Democritus' own theory of cosmic weight hardly impinges at all on Aristotle's criticism. That theory, as we know from Simplicius, and as we can infer in part from Aristotle himself, was that heavy and light in a cosmic vortex depend upon the action of ἐκθλιψις, with the expulsion of smaller atoms, or groups of atoms, towards the circumference of a *dine*. That theory is touched upon hardly at all in book four of the *De caelo*, and only once in the preceding books, when it is briefly refuted.²

But from this it does not follow that Aristotle's initial statement of the atomic theory of weight, as dependent upon size, is determined by his criticism of the inability of atoms, or of atoms and the void, to explain the diverse movements and stratification of the elements.

We need to look again at the context of the initial statement which I singled out for analysis, *De caelo* iv 2, 309a1-2: βαρύτερον αὐτῶν.³

Later in book four of the *De caelo* Aristotle will claim that

¹ *Greek Atomists* 145.

² The ἐκθλιψις is first mentioned at *De caelo* i 8, 277a33-b2. Aristotle does not here refer to Democritus by name. The attribution has to be supplied from Simplicius and from other authors, see above p.153 n.3.

In the fourth book, cap. 2, 310a10, the theory of an ἐκθλιψις is introduced briefly into an account of the definition of weight 'by largeness and smallness', a definition which I shall argue, in my third essay, is primarily intended to represent Ionian ways of thinking, but which is loose enough to include features from the other two main theories of weight that are criticised in book four, the theory of Plato and that of Democritus.

³ See ch.III § 1, pp.80–100 above.

Plato and Democritus are in the same boat, and he will apply to both equally the criticism which I have outlined. But at this point Aristotle has not yet subjected the Atomists to the same form of criticism as Plato. Aristotle's point here, if my earlier analysis is correct, is that the Atomists avoid the immediate *naïveté* of a simple equation of size and weight by their introduction of void, although that simple equation did in fact apply on the level of the primary elements, where the larger is also the heavier, and with more justification for the Atomists than for Plato, since for the Atomists the primary elements are at least solids, and not mere surfaces, from which no body can ever be generated.

I have repeated Aristotle's point in all its complexity, to show how far Aristotle is at this point from any immediate concern with a cosmos or with movement within a cosmos. It is only later, when Aristotle treats Plato and Democritus as alike having failed to explain the stratification of heavy and light elements, that Aristotle persistently reverts to the notion of the atoms having downward movement within a cosmos. In a looser sense, we may perhaps allow that the notion of compound bodies in the definition of lightness in terms of void, and the comparison of gold and fire in what I have called Aristotle's 'corollary', renders the context of that definition a cosmic one. But at the precise point at which Aristotle treats of the atoms themselves as having weight proportionate to their size it is the primary elements, whether surfaces or solid particles, which are the object of attention. At this juncture, Aristotle is not considering how successful their performance might be in explaining the stratification of elements within a cosmos. The context is not therefore a cosmic one, in any active sense.

It is therefore unreasonable, it seems to me, if not impossible, to explain the attribution of weight to the atoms, at this point in Aristotle's argument, as solely the product of his envisaging the atoms as constituting, or as representing, the stratification of elements within a cosmos.

**Chapter Ten—
The Nature and Distribution of the Evidence:
Secondary Evidence**

**§ 1—
Simplicius**

As I have noted, Simplicius' extensive transcriptions of fifth-century texts, which, however surprising it may seem, were still available to him long after they had ceased to form part of the current, or even occasional, reading of most other learned men of late antiquity, place him among the most important individual sources that survive for the reconstruction of early Greek philosophy.

However, by an unfortunate conjunction of circumstances, the character and intentions of Simplicius himself have been largely neglected by modern scholars. This is in part because Simplicius has been the victim of his own generosity. So conscientious and so liberal is Simplicius in his quotations from early writers that verbatim quotations can be extracted from his commentaries with little attention to the context from which they have been taken. At the same time, Simplicius' attempt to reduce the pre-Platonic philosophers to conformity with the essential principles of his own form of Platonism falls foul of the frequent modern English lack of interest in, and even dislike of, all forms of the Platonism of late antiquity, no matter what more particular guise they may appear in. The consequence is that anything more than the most superficial dipping into the sentences which immediately precede or follow Simplicius' quotations from the early philosophers seems to be considered a task as unworthy for the modern critic as it is unnecessary.

Such an attitude is not unscholarly merely. It is intellectually stultifying and even inconsistent. For the historian of philosophy, if such the student of Presocratic philosophy conceives himself to be, should be as well able to extend his historical sympathies to the latest as to the earliest philosophers of Greek antiquity.

Once we do so, we find that Simplicius occupies in fact a distinctive and an honourable position among his contemporaries.

For the syncretism which he attempts to cast upon the writings of the early philosophers is the result not of any mere intellectual flaccidity. It is an attempt, well-meaning enough in its purpose, however misguided it may be in the means which it adopts, to rescue the Presocratics from the contempt and ridicule of those of his contemporaries who, he tells us, absorbed with theological niceties and with sectarian bickerings themselves on occasion dipped into the records of the first philosophers, and were scornful of what they found there.

Thus after transcribing a history of the *ἐναρμονίως ὁμῶς συμφέρονται*.

'This then is an abbreviated summary of opinions and beliefs that have been held in the past on the subject of the first principles of philosophy and ontology.

'The theories in question have not been listed in chronological sequence, but according to the intrinsic affinity of the views and opinions held.

'It is important that the recital of such great discrepancies on the subject of the first principles should not mislead the reader into thinking that these reflect so many actual contradictions among those who practised the art of philosophy in ancient times.

'That is the impression which certain contemporary scholars have formed on coming across records that are purely historical and doxographical. Without understanding a word of the speculations that are therein recorded, they set out to try to blame the early philosophers for their want of consistency.

'This is the more ironical, in that they themselves are split up into thousands of different sects, and are divided by as many differences of belief.

'Not indeed that their bickerings touch upon the first principles of physical philosophy: of such studies they have not even the faintest glimmering. Their own disputes turn on the scrupulous purification of the divine transcendence.

'Nonetheless, it is perhaps as well to turn aside for a moment from the main current of our enquiry in order to demonstrate to those of our colleagues who have more of a taste for true learning, how it is that, despite the appearance of disagreement among the philosophers of ancient times in their beliefs and opinions touching upon the first principles of philosophy, in truth they do agree and their teachings form a harmonious and consistent whole.'

The analogy between the treatment of the Presocratics by Simplicius' contemporaries, and the attitude displayed towards Simplicius and his contemporaries by some modern scholars, would be amusing perhaps, if it were not so sad.

As it is, perhaps the most striking instances of modern antipathy towards Simplicius are provided by the question of weight.

Thus Liepmann writes of Simplicius, in relation to a whole range of sources, Alexander, Aetius, Cicero, Sextus, Diogenes Laertius, that he is 'von alien anzuführenden Zeugen für Democrit's Lehren der unglaublichste'.¹ The sentiment is echoed, if sometimes in a milder form, by a number of writers on the question of atomic weight.²

The more immediate reason for this antipathy is the belief that Simplicius must intend the atoms to move downwards in the void,

¹ *Mechanik* 39.

² Goedeckemeyer, *Epikurs Verhältnis* 23: 'Simplicius überhaupt . . . kein so einwandsfreier Berichterstatter ist, dass wir ihm aufs Wort glauben müssten'. Rivaud, *Le problème du devenir* 162 n.373: 'Les indications de Simplicius sont contradictoires . . . Simplicius a dû suivre des sources diverses'. (For Rivaud's loose handling of the evidence from Simplicius, see p.239 n.1 above.) Bailey, *Greek Atomists* 131, quotes Liepmann, and writes: 'With regard to the evidence of Simplicius it might be urged that to some extent he puts himself out of court by his own contradictions'. The only qualification intended is that 'an argument from inconsistency is never finally satisfactory'. Brieger had also written, *Urbewegung* 2: 'Simplicius . . . sich mehrfach auf das direkteste widerspricht'.

in virtue of his remarks about weight, and especially because of his assertion that the atoms 'move through the yielding and unresisting void in accordance with their weight'.

I hope to have shown that this conclusion is mistaken. Simplicius does attribute weight to the atoms, including, expressly and by implication, atoms which are outside a cosmos. But he does *not* thereby envisage the atoms as 'falling' in the void.¹

However, before turning to consider more specifically the relevance of this reading of the evidence in Simplicius to the evidence from Theophrastus and from Aristotle, it will perhaps be as well to consider rather more generally a number of passages where Liepmann and others seek to discredit the range of Simplicius' information about Democritus, and his powers of intellectual consistency when dealing with the intricacies of ancient Atomism.

The latter question is somewhat complex, and needs to be taken carefully.

§ 2—

The 'Parts' of Atoms: Simplicius' Powers of Intellectual Consistency

Brieger offers, as sufficient reason for disregarding Simplicius' account of weight in Democritus and in Epicurus, two passages, from the *De caelo* and the *Physics*, which turn on the question, whether or not Democritus' atoms have parts:

'An der einen Stelle werden den Atomen ausdrücklich Teile beigelegt, an der andern ebenso ausdrücklich abgesprochen.'²

(i)

Brieger does not refer to a passage which I have already alluded to, from later in the *Physics*, where Simplicius handles this very question with assurance, and with penetration.³

¹ *Phys.* 1318.30–1319.5 (in part DK 68A58), see above ch.V § 3, pp. 166–73.

² *Urbewegung* 7 (for *Phys.* 181b5 read 185b5); cf. 'Urbewegung' 587. The two passages are *De caelo* 612.11–17, where the atoms are *μόρια ἔχειν*: both passages are quoted below pp.272 and 274. Furley, *Two studies* 94–5, explains the passage in the *Physics* as a 'hasty reference' without considering the passage from the *De caelo*.

³ Cf. pp. 213–14 above.

Democritus and Leucippus, Simplicius writes, founded the indivisibility of the atoms on their *παρεῖ- λετο, ὡς διὰ τοῦτο ὑπὸ 'Αριστοτέλους ἐλεγχομένων* .

'Leucippus and Democritus rested the reason for their primary bodies not being subject to division, not only on their impassivity, but equally on their smallness and on their being without parts.

'Epicurus, later, does not account the primary bodies as being without parts. Instead he claims that it is because of their impassivity that they are "atomic".

'On many an occasion Aristotle controverted the theory of Leucippus and Democritus. It is presumably Aristotle's refutations of the atoms' being without parts which blocked the way for Epicurus on this point.

'Epicurus was in the position of working after Aristotle and yet of being in general sympathy and agreement with the theory of Leucippus and Democritus on the question of the primary bodies. He therefore retained the notion of the primary bodies being impassible, while at the same time abandoning the idea of their being without parts. He evidently calculated that it was this latter feature of the theory which had left the notion of primary atomic bodies open to refutation by Aristotle.'

After so clear a distinction between Epicurus and Democritus it

is possible perhaps, but unlikely, that elsewhere Simplicius should have confused the point. Examination of the two passages quoted by Brieger shows that, in all probability, he has not done so.¹

(ii)

In the passage quoted by Brieger from the *De caelo*, Simplicius is pursuing Aristotle's point that the notion of there being atomically particulate substances 'must needs be at loggerheads with the mathematical sciences' (ἀνάγκη μάχεσθαι ταῖς μαθηματικαῖς ἐπιστήμαις ἄτομα σώματα λέγοντας, iii 4, 303a20–2).

In elaboration of Aristotle's argument, Simplicius writes, 612.11–17 (not in DK): . . . διαιρετὸν καὶ μεριστὸν ;

'According to the mathematicians, nothing that is continuous is indivisible; on the contrary, every extended magnitude is divisible, and indeed infinitely so.

'Consequently, if the Atomists <believing, as they do, in "atoms"> do away both with continuity and with the infinite division of bodies <since a body that is not divisible cannot be continuous>, then they will find that they have done away with division in any form, and <thereby> no less with sensation <or perception, and indeed no less with self-perception> and consciousness.

'<Continuity of the body is essential to sensation:> for how could we be conscious of some feeling in our foot, if our bodies were not joined together and continuous?

'At the same time, <a body which is continuous must be divisible, and composed from elements that are divisible, for> how could anything that is divisible and that has parts

¹ For other evidence on the reason for the atoms' indivisibility, and in particular for the idea that Epicurus also retained hardness as a reason for the atoms' being indissoluble, see above p.245 n.1.

come to be formed out of elements that are indivisible and that have no parts'

In the final sentence of this passage, Simplicius speaks of Democritus' atoms as 'without parts' (ἀμερῶν). But it is important to appreciate that in this passage Simplicius does not intend to allow that the atoms, if they existed as extended magnitudes, could in fact be 'without parts'.

Simplicius, and Aristotle, agree with 'the mathematicians', at least when the terms of the problem are rightly understood, that 'every extended magnitude is divisible to infinity' (ἐπ' ἀπειρον πᾶν μέγεθος διαιρετόν), in the sense that it is potentially divisible at any one of an indefinite number of points. When therefore Simplicius asks 'how from elements that are indivisible and without parts could there arise a substance that is divisible and resolvable into parts?', he is in effect repeating the well-known *topos* of Aristotelean criticism, which we have come upon a number of times already, to the effect that 'no extended magnitude can be constructed of parts that are themselves without magnitude'.¹

In effect therefore, in his final sentence, Simplicius is, as it were, taking Democritus at his word and treating the atom virtually as though it were a point, which in terms of his own philosophy it would have to be if it were truly to be 'indivisible and without parts'. His criticism is then that from such an 'atom' there could never be constructed any sensible, or sentient, physical magnitude.

(iii)

Thus in the *De caelo* and in the *Physics* Simplicius writes of Democritus' atoms as *not* having parts.

In the passage quoted by Brieger from earlier in the *Physics* Simplicius speaks of Democritus' atoms as though they *do* have parts.

Simplicius is pursuing Aristotle's critique of the Eleatic One. His purpose is to distinguish three senses in which the one may be without division (ἀδιάρετον). The point will then be to show that no one of these senses can satisfy the Eleatic claim to unity.

¹Aristotle's longest discussion, *De caelo* iii 1, 299a25–300a19; cf. pp.84–5 and 214–15 above.

1. What is one may be divisible, but undivided.
2. It may be indivisible in principle, because without parts.
3. It may have parts, but be indivisible in practice.

The first possibility is exemplified by any normal continuous body; the second by a point or unit; the third by 'an atom of Democritus'.

Simplicius writes, *Phys.* 81.34–82.3 (not in DK): *ναστότητα, καθάπερ ἐκάστη τῶν Δημοκρίτου ἀτόμων*.

'If when the Eleatics claim that being is one they mean that it is indivisible, then they will have to mean that it is indivisible in one of the following senses, since "indivisible" is not a term that has a single meaning: (1) the "indivisible" may mean what is not yet divided, but what could be divided, and in this sense every continuous body <is "undivided" and yet divisible>; (2) it may mean something whose nature renders it incapable of division, incapable because it has no parts into which it could be divided, for example a point <in geometry> or a unit <in arithmetic>; or (3) it may mean something which <would be divisible> in so far as it does have parts, and in so far as it does have extension, but which is <in fact incapable of division because it is> impassible in virtue of its hardness and solidity, and this would be true of the individual Democritean atom.'

Now in other circumstances it would perhaps be quibbling to claim that *καθάπερ Δημοκρίτος φησιν εἶναι ἕκαστον τῶν ἀτόμων*. But in this instance, on careful reflection, I think not so.

For the context of this passage is very different from that of the context of the passage in the *De caelo*.

There are in truth, for Simplicius as for Aristotle, only two senses of material (as distinct from formal) unity.

1. There is the unity of an extended body which is divisible in principle but may be undivided in fact.
2. There is the unity of a point which is indivisible in principle or, one might say, by nature or by definition.

Therefore only the first two senses of unity listed above have real meaning for Simplicius, or for Aristotle. The third sense of unity must in fact reduce itself to one or other of the first two senses of unity.

1. If the 'atom of Democritus' is allowed to have parts, then it must be potentially divisible, like any other extended body, and so it will fall under the first head.
2. If on the other hand the 'atom of Democritus' is allowed to be indivisible, then it cannot have parts, and it must be identified with a unit or a point, and so fall under the second head.

In the passage that I have quoted from the *De caelo* Simplicius in effect adopts the *second* strategy.

In the present passage he takes the alternative path. The 'atom of Democritus' is engrossed under the *first* head, and the first and third senses of unity are resolved by the same criticism, *Phys.* 82.3–6 (following on immediately from the lines quoted above): πολλά.

'If being is one in the sense of what is continuous, then it again follows that being is multiple, <as it> also <does> if being <or what exists> is an "atom": it is of course <in itself> weird and disconcerting enough if all things are to be construed as a single "atom"; but the point is rather that the "atom" would itself be continuous and <therefore> divisible indefinitely, and for that reason <what exists> would be potentially multiple.'

Thus the distinction of the first and third senses of unity, a distinction which is not found in the corresponding passage of

Aristotle, has been introduced as something of a *jeu d'esprit*. It is not a distinction which has any permanent place in Simplicius' analysis. It is a typical example in fact of the kind of refinement and elaboration with which Simplicius likes to enliven his commentary.

At the same time, once Simplicius is committed to this distinction, however temporarily, it is difficult, indeed I think probably impossible, to envisage anything but an atom which could exemplify unity in the third and final sense. For what is needed here is an 'atom' which is claimed to be indivisible, and so is distinct from any normal continuous body, and yet which 'has parts', and so is distinguishable from a point or unit.¹

(iv)

Thus in considering the apparent contradiction between the *De caelo* and the passage earlier in the *Physics*, the point we need to appreciate is that an 'atom' occupies an ambiguous, and at root a conceptually impossible, position within the philosophy of Aristotle and of Simplicius.

1. In so far as it is reckoned as truly 'without parts', the atom ceases to be an extended magnitude and acquires the same conceptual configuration as a point.
2. In so far as it is reckoned as an extended magnitude, the atom must 'have parts', and so ceases to be truly 'atomic', in that it becomes subjected, at least in principle, to the possibility of division, and even of infinite division, within the proper bounds of the notion of potentiality.

The *first* way of looking at an atom is that employed in the *De caelo*, where the idea is that an extended and divisible magnitude cannot be constituted from elements which are indivisible and

¹ In a different context, in the *Metaphysics*, 631.8–11, Alexander offers as an example of things that are 'one and undivided', other than number, '<each of> the flecks of dust that can be seen in the sun's rays'. The same image had been used by the Atomists as a description of their soul-atoms (Arist. *De anima* i 2, 404a16–20, cf. pp.177–9 above). Alexander's indirect use of the atomic theory may explain Simplicius' use of the same idea in the present passage (for Simplicius' criticism of the text from the *De anima* see below pp.279–81).

'without parts': on this view the atom is treated in effect as a point or a unit.

The *second* way of looking at an atom is that employed in the earlier passage of the *Physics*, where the idea is that an atom represents the impossible claim to a unit which has parts but which is undivided and indivisible: an impossible claim (for Simplicius, as for Aristotle), because if the atom has parts then it becomes extended, and so must be divisible at least potentially.

These two ways of looking at an atom are signalled in the two passages in question by the conjunction of the *first* way of looking at an atom, in the *De caelo*, with the notion of *indivisibility*, and by the conjunction of the *second* way of looking at an atom, in the earlier passage of the *Physics*, with the notion of an *extended magnitude*.

1. In the *De caelo*, Simplicius takes the atom as truly indivisible and therefore 'without parts': ἐξ ἀδιαίρετων καὶ ἀμερῶν...

From this he argues that the atom cannot form the basis of sensible extended magnitudes.

2. In the earlier passage of the *Physics*, Simplicius allows the notion of the atom as an extended magnitude and therefore as 'having parts': ἢ τῷ μόριον μὲν ἔχειν καὶ μέγεθος.

From this he argues that if the Eleatic unity is construed in this sense then it cannot be truly impervious to division and multiplicity.

The point is that the two categorisations, that of being an extended magnitude and that of being indivisible, are joined in Democritus' conception of an atom, but for Simplicius, and for Aristotle, their conjunction is conceptually impossible.

Thus, for different purposes, the atom is treated *either* as being the one thing, indivisible, and therefore as 'without parts', as it is in the *De caelo*, or as being the other thing, an extended magnitude, and therefore as 'having parts', as it is in the earlier passage of the *Physics*.¹

¹ The difference is not the result of a change in Simplicius' own interpretation of ancient Atomism. Only a page or two before the passage quoted from the *De caelo*, Simplicius takes what is virtually the point of view adopted in the passage

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Conclusion

(i)

It is true therefore that there remains a formal inconsistency, in that in the earlier passage of the *Physics* Simplicius allows that the atoms of Democritus 'have parts', while he denies this historically in the later passage of the *Physics* and conceptually in the *De caelo*.

In fact, however, the later passage of the *Physics* shows clearly, I think, that Simplicius is not himself confused on the point at issue, either conceptually or historically.

It therefore seems to me quite probable that the somewhat curious turn of expression in the earlier passage of the *Physics*, *καθάπερ ἐκάστη τῶν Δημοκρίτου ἀτόμων*, is intended as an indication that this 'atom' is not the impossible hybrid conception of an atom which Democritus himself actually described, but the atom as it would have to be on Aristotle's terms, i.e. an 'atom' as an extended magnitude and therefore as 'having parts'.

It will in fact therefore be the same as, or at least on this point equivalent to, the atom of Epicurus, although in considering, as he is, the fifth-century Eleatics, Simplicius fairly naturally turns to the earlier system.

(ii)

If this explanation of Simplicius' behaviour is accepted, then as before on the question of movement this issue will turn out to convey precisely the opposite lesson to that alleged by those who have sought to dismiss or to discredit Simplicius' evidence.

1. I concluded earlier that Simplicius recognises that the atoms of Epicurus fall in the void, whereas Democritus' atoms 'dart about', as it were at random. Simplicius' attribution of weight to Democritus' atoms is the less likely there-

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quoted from the *Physics* (81.34–82.3). The individual atoms are here allowed to be 'continuous', and the Atomists' 'doing away with division' results not, as in the later passage (612.11–17), from the fact that the individual atoms are incapable of division, but because 'division' is merely the separation of one atom, or group of atoms, from another: see *De caelo* 609.19–25.

fore to be simply the result of confusion with Epicurus.¹

2. I now conclude that if Simplicius can distinguish Epicurus and Democritus as clearly, and as acutely, as I believe he does on the question of the 'parts' of atoms, then he is again the less likely to have confused the two on the question of the weight of atoms.²

§ 3—

The Nature of Soul: Simplicius' Information on Democritus

Liepmann quotes from Mullach the claim that in his *De anima* Simplicius writes, in relation to Democritus' theory of the soul's activity as maintained by breathing, that:

'Aristoteles spräche sich über den vorliegenden Fall nicht ganz klar aus'.³

This formulation blurs an issue which is crucial to our enquiry. Simplicius does not complain that he cannot discover the facts of Democritus' theory, which I think is the implication that the sentence I have quoted from Liepmann is intended to bear, or at least the implication which it will convey.

What Simplicius complains of, is that he cannot determine whether the theory of small round atoms as constituting soul was intended by Democritus literally or whether the sphericity of the atoms was intended paradigmatically, as an illustration of the

¹ Cf. pp.163–73 and 192–202 above.

² Lest the reader thinks that I am offering too idealised a picture of Simplicius' powers of intellectual consistency, he may like to remember that on one crucial point I do believe that Simplicius has had trouble in reconciling his ideas: the effectiveness of weight in a void, and the nature of movement as 'division'. But in this case I believe that Simplicius has had to grapple not only with Epicurus' reformulation of the atomic theory, in answer to Aristotle, but with Alexander's extension of Aristotle's argument as a rebuttal of Epicurus, and also with Philoponus' radical attack upon Aristotle's conception of motion—a daunting prospect, where Simplicius is not alone in failing to see the way clearly. I pursue this point in my fourth essay; meanwhile see above ch.VI § 3, pp.195–202.

³ Liepmann, *Mechanik* 39. Mullach, *Democriti fragmenta* 112–13. Cf. Brieger, *Urbewegung* 3–4, and Papencordt, *Atomicorum doctrina* 22. On the disputed authenticity of the commentary on the *De anima* see above p.226 n.1.

soul's intellectual substance. For on such a point, he argues, one cannot rely on Aristotle, who in Simplicius' eyes was notoriously liable to take only the superficial sense of the writings of the early philosophers.

Simplicius writes, *De anima* 26.11–19: δὲ ἴσως τὴν ἤδη μερίζο- μένην τῆς ψυχῆς οὐσίαν καὶ εἰς τὸ φανερόν προῖοῦσαν .

'We are not in a position to determine whether, in adhering to the theory that has been described, Democritus intended <the heresy of> generating life from material substances, or whether his purpose was to reveal (ἐνδεικτικῶς δηλοῦν) the nature of intelligible substance through <his employment of the image of> the sphere.

'On such a matter one cannot rely on Aristotle's historical writing. Over this whole field of enquiry, he does no more than set out the obvious and the superficial sense of the writings of the early philosophers.

'This is apparent in the case of the theory which he brings forward in connection with the Pythagoreans.

'He records Democritus' claim that the elements are analogous to the motes which one sees in a shaft of sunlight. He then adds that certain of the Pythagoreans believe that motes seen in the air actually are the fundamental particles themselves.

'No member of the Pythagoreans would ever have thought such a thing. What they may have intended, was to afford an indication of how in this world (ἤδη) the substance of soul is subjected to processes of division, when she issues forth from the higher world into the unfolding and manifestation of her powers here below.'

It is true that from this passage we can deduce that Simplicius

does not lay claim to any of the original writings of Democritus, or at least not to any original writings on this subject. For in other cases where he did have original texts, from Parmenides, Anaxagoras, Empedocles, Diogenes, not only does Simplicius quote from them extensively, but he is perfectly happy to decide the question of their 'true' meaning, and at least in the first three cases to correct what he sees as Aristotle's falsely superficial interpretation by restoring to the early philosophers the intellectual idealism which their poetical and picturesque terminology is able to reveal to the eyes of a Platonist.¹

Simplicius' inability to do the same for Democritus shows that he does not have Democritus' original writings. But it does not show that he considers himself to be lacking in information about what I may perhaps call the facts of Democritus' theory.

The distinction is a significant one, for elsewhere Simplicius shows that he has to hand (if that is not too fanciful an expression for 'is able to quote at length from and to refer to') Aristotle's treatise on Democritus, and an extensive version either of Theophrastus' *Physicorum opiniones* or possibly of a later redaction of the same material taken from Theophrastus' own treatise on physical philosophy.

With these materials to hand, Simplicius nowhere complains of his inability to determine the facts of early Atomism. What he complains of, on this one occasion in the *De anima*, is his inability to determine for himself their true purport.

It is Simplicius' possession of these two works which will provide, I believe, the turning point in our enquiry, when finally we consider the probability of Aetius' denial of weight to the atoms.²

¹ Leading passages are *Phys.* 20.28–42.5, 115.10–121.25, 133.30–190.20, 1183.1–1186.35, *De caelo* 556.1–562.18, 603.4–609.12. Simplicius notes at one point that even Alexander is 'unimaginative and lackadaisical' in his attitude towards the Presocratics, *Phys.* 80.16–17: ξηρότερον καὶ ἀφερεπώνως τῶν παλαιῶν ἀκούειν δογμάτων.

² My remark about a later redaction of the *Physicorum opiniones* is intended as a concession—I think probably an unnecessary concession—to Steinmetz's thesis: see p.4 n.1 above. Simplicius' quotations from Theophrastus are printed in Diels, *Doxographi graeci* (Berolini, 1879) 473–95. Simplicius' quotation from Aristotle's work 'On Democritus', *De caelo* 294.33–295.20 (fr. 208 Rose = DK 68A37), is taken account of in my next chapter, pp.303ff. In writing of Simplicius' 'possession' of these two works, I do not of course mean that he necessarily possessed both

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§ 4—

Aetius and the Size of Atoms

The collection of *Placita* attributed to Aetius is the most difficult and treacherous work for anyone seeking to disentangle reliable evidence for fifth-century philosophy from the silences and distortions of later writers.

Aristotle's prejudices have at least a certain consistency. The continuous surviving portion from Theophrastus' history may cover only a limited range of subjects; but Theophrastus does there at least attempt to disengage reported fact from criticism. The very freedom of Simplicius' platonising interpretation of the Presocratics leaves him with little need, or incentive, to tamper with the details of their theories.

In each of these cases, therefore, there is something to lighten the historian's task. By contrast, in Aetius the possibilities of confusion are legion. For here we have to contend with the prejudices and the ignorance not of one author, but of several authors, of whose personalities and background it is virtually hopeless to try to form any individual impression.

There are however two truths, and perhaps only two, which are worth retaining as guidelines to the interpretation of the whole: first, Aetius' dependence upon Theophrastus, and secondly the constant possibility, throughout the *Placita*, of gross error, particularly in any entry which touches upon any larger question of principle, where there is a correspondingly greater possibility of ideological influence.¹

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works in their entirety, only that he knew more of them than we do: see p.300 n.1 below.

The list of Aristotle's writings in Diogenes Laertius records both a work in one book *πρὸς Δημόκριτον*.

¹ Diels writes, *Dox.* 219: 'Theophrasti corpus non dubium est, quin in Ionicis philosophis . . . fons fuerit primarius. . . . veri simile est de . . . Leucippo Democrito Metrodoro Chio. quamquam de atomorum doctoribus est quod dubites. neque enim usquam tam saepe dedit scriptor inscitiae poenas quam in illorum dogmatis'.

I take each point in turn, as it affects our present enquiry, and first the presence of gross error in Aetius' report on Democritus.

'An Atom As Big As a World'

(i)

In the entry we are primarily concerned with, the possibility of gross error is exemplified by the words which follow directly the denial of weight and its relation to the question of movement, i 12.6 (DK 68A47): δυνατόν <δ'> εἶναι κοσμοαῖαν ὑπάρχειν ἄτο-μον. '<Democritus says> it is possible for there to be an atom as big as a world.'¹

The idea of very large atoms reappears in Eusebius, in the chapters where he is quoting from Dionysius, bishop of Alexandria. Dionysius explicitly distinguishes the atoms of Epicurus, which are 'all very small, and for that reason cannot be perceived', from Democritus' atoms, 'some of which are very large'.²

Proof, if proof is needed, that this is false, is at once provided by Aristotle.

1. In the *De generatione et corruptione* Aristotle writes of Leucippus' atoms that they are 'invisible because of their smallness', i 8, 325a30 (DK 67A7):

ἀόρατα διὰ σμικρότητα τῶν ὄγκων.

2. In the fragment which Simplicius has recorded from the treatise *On Democritus*, Aristotle writes that the atoms are 'so tiny that they lie wholly below the threshold of our

¹ The whole entry has been quoted, p.223 above. I take the meaning of κοσμοαῖος to be 'as big as a world', as given in LSJ s.v., although no other use of the term is there recorded.

² Eus. *Praep. evang.* xiv 23.3 (DK 68A43). It is usual to quote these two passages together, although if the atoms vary in size some will inevitably be 'the biggest' even if all the atoms are very small. But the contrast with Epicurus does make it look as though Dionysius has something more than this in mind. Diogenes' description of the atoms as 'infinite in size' (ἀπείρους κατὰ μέγεθος, ix 44 = DK 68A1), is taken account of below, pp.289–90.

Interestingly, Simplicius at one point also arrives at the conclusion that the whole world, or 'all things', would be 'one atom', though by a route that is perhaps unlikely to have found its way into a doxographical collection: see *Phys.* 82.5, above pp.275–6.

perception', *ap. Simplicius De caelo* 295.6 (fr. 208 Rose = DK 68A37): οὕτω μικρὰς τὰς οὐσίας, ὥστε ἐκφυγεῖν τὰς ἡμε-τέρας αἰσθήσεις .

(ii)

It is true that Aristotle's evidence on this point has been discounted—when it has not been simply ignored.

Thus the idea that Democritus did believe in very large atoms has been defended, notably in a series of articles by Charles Mugler.¹ In the first of these articles Mugler writes that:

'L'hypothèse d'atomes dépassant toute limite (*sc. de grandeur*) est donc non seulement compatible avec la cosmologie générale des premiers atomistes, mais elle en constitue une des représentations fondamentales.'²

It is symptomatic, however, that both in this article, and in his most recent contribution to the subject, Mugler starts his argument by quoting the passage from Simplicius, but without noting that it occurs in the course of a quotation by Simplicius from Aristotle.³

This omission possibly helps to explain the error whereby M. Moraux, in the Introduction to his Budé edition of the *De caelo*,

¹ C. Mugler, 'Sur quelques particularités de l'atomisme ancien', *Rev. de phil.* série 3, année et tome 27 (1953) 141–74, 'L'isonomie des Atomistes', *Rev. de phil.* série 3, année et tome 30 (1956) 231–50, 'Les théories de la vie et de la conscience chez Démocrite', *Rev. de phil.* série 3, année et tome 33 (1959) 7–38, esp. 9–13, and 'L'invisibilité des atomes, à propos d'un passage d'Aristote (*De gen. et corr.* 325a30)', *REG* 76 (1963) 397–403. There is a certain coincidence between the views of Mugler and the opinion briefly given by Solomon Y. Luria, *Outlines of the history of ancient science, Greece in her prime* [in Russian] (Moscow and Leningrad, 1947) 190–1.

² 'Quelques particularités' 147.

³ 'Quelques particularités' 145. 'L'invisibilité des atomes' 397, see also p.400 n.5. Since Mugler fails to recognise the passage from Simplicius as a quotation from Aristotle, he is led to reconstruct an elaborate difference of doctrine for Leucippus and for Democritus, 'La vie et la conscience' 9ff. But since the fragment from the treatise *On Democritus* repeats, for Democritus, virtually what Aristotle states for Leucippus in the *De generatione et corruptione*, this part of Mugler's thesis seems to me wholly aberrant. I have already noted my disagreement with the moves made in the same direction by Bailey, *Greek Atomists* 78ff. and 125ff., cf. pp.4–5 above.

attributes to Aristotle himself the thesis that for Democritus there were 'very large atoms', p. cxlv:

'... il est hors de doute que les Abdéritains attribuaient aux atomes des grandeurs diverses et n'hésitaient pas à en imaginer de très gros. Cette thèse, *rapportée par Aristote*, est confirmée par les critiques qu'Epicure adresse à ses prédécesseurs' (my italics).

So far as Aristotle is concerned, the truth is just the opposite of this. Aristotle does say that Democritus' atoms 'differ in size'.¹ But on the evidence of the two passages already quoted it must follow that, for Aristotle, these differences of size fall wholly below the threshold of our perception.

(iii)

What of Epicurus? M. Moraux has quoted two passages where he claims that Epicurus intends to criticise his predecessors' belief in 'very large' atoms.²

In the first passage quoted by Moraux, Epicurus argues that if there could be 'every size' among the atoms then some atoms would be visible. This has frequently been taken as criticism of Democritus.³ But there is in fact nothing to show that the 'visible' atoms are intended as the rebuttal of a belief actually held, and not simply as a *reductio ad absurdum*.

The passages already quoted from Aristotle are clear enough evidence, it seems to me, that at this point Epicurus cannot mean to criticise Democritus directly, unless we are to suppose that Epicurus has misunderstood Democritus, a bizarre, and certainly in this instance not a necessary, supposition, although one that on other points some writers do not shrink from.⁴

¹ Phys. iii 4, 203a33-b2 (DK 68A41); *ap. Simpl. De caelo* 295.7-8 (fr. 208 Rose = DK 68A37).

² *De caelo* Budé edn cxlv n.3: *Ep. ad Her.* 55 and 61.

³ *Ep. ad Her.* 55-6; cf. Guthrie, *History ii* 395 n.1, Graziano Arrighetti, *Epicuro opere* 2nd edn (Torino, 1973) 507.

⁴ Alfieri's suggestion that Epicurus misunderstood Democritus has been noted, p.186 n.2 above. Guthrie, *History ii* 395 n.1, repeats Bailey's suggestion, *Epicurus* 204, which is not that Epicurus misunderstood Democritus, but that

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(iv)

The position is slightly more complicated in the second passage quoted by Moraux. Epicurus here denies that large or small atoms travel with differences of speed, and concludes that all atoms travel with the same speed, no matter what their size. I have myself argued that in this passage Epicurus may intend to criticise Democritus.¹

But the chapter is also a statement of Epicurus' own belief. It is essential to distinguish between these two features of the passage.

1. Epicurus' criticism—if such it is—will bear solely on the question of there being different speeds for different sized atoms.
2. The conclusion that both large and small atoms travel all with the same speed is intended, not as criticism, but as a statement of Epicurus' own belief.

The 'large' and 'small' atoms are the subject both of the criticism and of the conclusion to the argument. They must therefore include Epicurus' own atoms. These Epicurus has already told us fall wholly below the level of our sensible perception.²

(v)

The truth is that most writers seem to be so taken up with the intellectual interest of 'very large' atoms that they quite fail to give sufficient attention—or any attention—to the conflict in the sources of our information.

For example, in the notes to his edition of the *De generatione et corruptione*, Mugler does admit that 'Aristote semble ignorer que

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Democritus failed to see the consequence of his own ideas: Democritus 'posited atoms in an infinite variety of sizes', and failed to see that 'this would inevitably involve visible atoms'. This again seems to me a quite unnecessary hypothesis, since there is no good evidence that Democritus did claim his atoms showed an 'infinite variety of sizes'. Guthrie has also failed to see the point that an 'infinite variety of sizes' does not in fact require the presence of 'every size' among the atoms, and need not therefore entail the belief in visible atoms: see further p.289 n.2 below.

¹ *Ep. ad Her.* 61, cf. pp. 184–5 above; see also pp.325–6 below.

² *Ep. ad Her.* 55–6.

Démocrite admettait l'existence d'atomes de toute grandeur'.¹

But Mugler quite fails to ask himself how a theory, not known to Aristotle, found its way into Eusebius and Aetius.²

In the light of the repeated evidence from Aristotle, it seems to me unnecessary to make even the more moderate concessions to the idea of 'very large' or visible atoms that are found in several writers.³ For example, there is little point, it seems to me, in writing that Democritus may have believed in atoms that were 'comparatively large'.⁴ No mere compromise can bridge the gap between the evidence in Aristotle and the evidence in Aetius.

1. According to Aristotle, the atoms, whether of Democritus or of Leucippus, were 'invisible because of their smallness', and 'so tiny that they lie wholly below the threshold of our perception'.

2. Aetius' assertion that Democritus believed in the possibility of an atom 'as big as a cosmos' is therefore, it seems to me, plainly in error.

The question which concerns us here is: how did this error arise? The answer to this question proves to be somewhat complex, but it is, I think, worth pursuing, for the sake of the light which it throws on the closely parallel problem of Aetius' denial of weight to the atoms.

'Infinite in Size'

(i)

Diels suggests that error has arisen from confusion with gods in the *intermundia*, whom Cicero describes as being *ingentes quas-*

¹Budé edn 88–9.

²Guthrie recognises the doxographical weakness of Mugler's thesis, *History* ii 395 n.1. But when Mugler launches into an elaborate description of the 'world-sized atom' falling upon, and destroying, an inhabited cosmos ('L'invisibilité des atomes' 399ff.), Guthrie finds his 'apocalyptic vision . . . impressive'; so it is, but only as science fiction.

³for example Robin, *La pensée grecque* 139, Bailey, *Greek Atomists* 125–8, Kirk, *Presocratic philosophers* 408–9, Sambursky, *the physical World of the Greeks* 408–9 cf. 110–11, Strohmaier, 'Die Sonnenstäubchen' 13.

⁴Kirk, *Presocratic philosophers* 408 n.1: see further pp.293–4 below.

*dam imagines, tantasque ut universum mundum complectantur extrinsecus (De natura deorum i 43.120).*¹

This might perhaps explain the size. But how did 'images' of the gods come to be identified with individual atoms? There is no obvious motive for this conflation of ideas.

A more fruitful line of enquiry, it seems to me, would be to suppose that error has arisen from a simplification of the original theory. Aristotle offers a host of formulations which describe the atoms in various ways as:

'infinite in number, infinitely variable in shape, and variable (but not infinitely so) in size'.²

It would be possible for the qualification to fall out, so as to yield the notion that the atoms are:

'infinite in number, and infinitely variable in shape . . . and in size'.

An extreme consequence of this simplified formulation of the theory could then be highlighted, for popular consumption, rather like the headline in a modern newspaper: 'World-sized atom a possibility'.³

¹Dox. 219 n.4.

²'Infinite in number': De caelo iii 4, 303a5–6 (DK 67A15), cf. 303a10b–8, *De gen.* et corr. i 2,315b9–11 (DK 67A9), i 8, 325a30 (DK 67A7), ap. Simpl. *De caelo* 295.2 (fr. 208 Rose = 68A37). 'An infinite variety of shapes': De gen. et corr. i 8, 325b27–8 (DK 67A7); cf. Theophrastus, ap. Simpl. *Phys.* 28.4–7 (Dox., *Phys.* op. fr. 8 = DK 67A8 and 68A38). 'Infinite in number and shape', De gen. et corr. i 1, 314a21–3 (DK 67A9). 'Infinite in number and differing in shape': *Phys.* i 2, 184b20–2 (cf. DK ii 115.7 note). 'Differing in size and in shape': *Phys.* iii 4, 203a33–b2 (DK 68A41), ap. Simpl. *De caelo* 295.7–8 (fr. 208 Rose = DK 68A37).

³The omission of a qualification distinguishing shape or number from size may seem rather far-fetched. But it is in fact one of several *glissements* that appear in Mugler's handling of the subject. He writes, 'Quelques particularités' 143, 'Il paraît naturel de prêter aux atomistes pour la grandeur des atomes des conceptions et des raisonnements analogues à ceux par lesquels ils justifiaient la variété infinie de la forme des atomes', and 143 n.1: 'Si ce témoignage de Simplicius n'affirme rien de précis sur la marge de la variation de grandeur des atomes, il suggère du moins, par le voisinage du μέγεθος, l'hypothèse d'une variation de grandeur aussi étendue que celle de la forme'. The hesitant note ('il paraît', 'suggère') soon disappears, and an infinity of number, shape and size is presented, with no qualification (p.147), as 'les trois aspects' of 'physical infinity'

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(ii)

It is true that this line of enquiry may seem to take us further than we need: even a 'world-sized' atom is not 'infinitely' large.

And yet something akin to the idea of 'infinite size' does appear to underly the material recorded by Diogenes, in his *Life* of Democritus, where 'the atoms are infinite in size and in number', ix 44 (DK 68A1): καὶ τὰς ἀτόμους δὲ ἀπείρους εἶναι κατὰ μέγεθος καὶ πλῆθος.

These words have been very variously interpreted. Even in a doxographical compilation, it is difficult to believe that 'the atoms' without qualification, '<all> the atoms' therefore, should have been thought to be 'infinite in size' in the sense of 'infinitely large'. And yet the meaning cannot be that the atoms are 'infinitely small', as Miss Freeman supposes, for this would conflict with the belief in indivisible magnitudes.¹

It seems possible therefore that the writer does here intend the atoms to be 'infinite in <variations of> magnitude'. As before this idea could encourage the belief that some atoms are 'very large', and therefore that there could even be an atom 'as large as a cosmos'.²

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for Democritus. But the truth is that the passage quoted (p.143 n.1: not 'Phys. p.36'; it must be *De caelo* 295.7–8, Arist. fr. 208 Rose = DK 68A37) affords no justification for Mugler's conflation of shape and size.

¹ Kathleen Freeman, *The Pre-Socratic philosophers, a companion to Diels, 'Fragmente der Vorsokratiker'* (Oxford, 1946) 299–300.

² Mugler is, I believe, right to claim, 'La vie et la conscience' 9, that: 'il peut y avoir une infinité d'espèces d'atomes de grandeurs différentes comprises entre deux valeurs finies'. This need not conflict, as Guthrie thinks, *History* ii 394 n.2, with a denial of 'the notion of the infinitely small', for in the series 1, 1½, 1⅓, etc., it is only the increase in size which is ever smaller, the total size of each atom will always be greater than 1 and less than 2. From the note following, *History* ii 395 n.1, it appears that Guthrie, as also Bailey, *Epicurus* 204, has confused the idea of an infinite increase in size with Epicurus' denial that there can be 'every size' among the atoms (*Ep. ad Her.* 55–6). The Epicurean notion of the smallest 'part' of an atom (cap. 59) would require an infinite variation in size to yield an atom infinitely large. But if there is no 'smallest part' then the amount of increase can be ever smaller, so that there could still be a limit to the size of the largest as of the smallest atom.

My point, therefore, is not that Diogenes' formula must in fact entail atoms 'very large' or 'infinitely large', but that what was permitted in theory may well have been neglected in practice—as in fact it is by Guthrie and by Bailey. An infinite increase in size, which could in principle be contained between two finite

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(iii)

A different interpretation of Diogenes' words is given by Zeller, who endorses Brieger's explanation of the formula 'infinite in size' as 'ein ungeschickter Ausdruck dafür, dass die Gesamtmasse der Atome unendlich gross ist'.¹

There are two disadvantages to Zeller's interpretation. First, it collapses the usual distinction between μέγεθος as respectively discrete and continuous quantity.² Secondly, even if we do agree to consider the 'whole mass' of atoms as 'infinite in size', this fact then becomes a mere duplication of the claim that the atoms are 'infinite in number'.

But it is perhaps possible to see in Zeller's interpretation an alternative source of error to the one I have already suggested. Possibly the meaning intended is—or was, at some stage in the transmission of material copied out by Diogenes—that the whole agglomeration of atoms is 'infinite in extent', in the sense that the space in which the atoms are disposed is infinite.

The two words (πληθος) are juxtaposed with this meaning in Aristotle's account of Democritus and in Aetius: the atoms are 'infinite in number' and the void or the place which they occupy is 'infinite in extent'.³ The same two ideas and the same expressions recur in Epicurus: 'the whole is without limit both in the number of bodies and in the extent of the void'.⁴

I could believe that from these or similar expressions the distinction between atoms and the void has fallen out, leaving only the ambiguous, and potentially misleading, assertion that the atoms are 'infinite in <size or> extent and in number'.

This formulation could either have encouraged, or have been encouraged by, the belief that Democritus' atoms were 'very large' and could be 'as big as a cosmos'.

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magnitudes, was thought to require an atom infinitely large, either through a mistaken notion of 'infinity' (an infinite series of sizes need not in fact include every possible size), or perhaps more probably because the Epicurean theory of the 'smallest part' excluded the possibility of an ever smaller increase.

¹ ZN 1083 n.2: Brieger, *Urbewegung* 4.

² On this point, cf. C. Mugler, 'Platonica § III', *L'antiquité classique* 25 (1956) 28–31.

³ Arist., ap. Simplicius, *De caelo* 295.1–3 (fr. 208 Rose = DK 68A37). Aetius i 18.3 (DK 67A15).

⁴ *Ep. ad Her.* 41. Bailey's mistranslation, *Epicurus* 23, of ἀπειρόν ἐστι τὸ πᾶν as 'the infinite is boundless' reduces this sentence to a tautology.

Epicurus and the 'Parts' of Atoms

(i)

However, we can discover, I think, another and yet more compelling, cause of confusion.

Democritus' theory is that there are infinite variations in the shapes of atoms, and gradations, but not infinite gradations, in size.¹

Epicurus allows that the atoms are infinite in number, but denies that there can be infinite differentiations in shape or in size.²

Epicurus' adjustment to the original theory might encourage a doxographical writer to polarise the final formulations of the two theories.

1. For Epicurus, the atoms are infinite in number, and variable, but not infinitely so, in shape and in size.
2. For Democritus, the atoms are infinite in number, and infinitely variable in shape and in size.

But we can go further. Lucretius *connects* the two elements which I have quoted from Epicurus, by arguing that infinite variations in shape would require infinite gradations in size (ii 478–99).

Lucretius' argument provides us with what is perhaps the most probable reason for the error in Aetius. The writer in the *Placita*, I would suggest, has adopted the argument which Lucretius deploys, and has used it to try to increase, or to clarify, his understanding of Democritus.

1. In order to vary infinitely in shape, the atoms must vary infinitely in size.
2. Democritus atoms do vary infinitely in shape.
3. Therefore they must vary infinitely in size.

Therefore, an extreme case: 'it is possible for there to exist an atom as big as a world'.

¹See the passages quoted p.288 n.2 above.

²*Ep. ad Her.* 41–2 (number), 42 (shape), 55–9 (size).

(ii)

Significantly, while Epicurus himself initially speaks only of the need to avoid 'atoms large enough to be seen', as sufficient reason for there not being 'any and every size among the atoms', Lucretius denies that there can be an atom *immani maximitate*. This is just the kind of exaggeration that appears in Aetius.¹

It is still more significant if we consider the content of Lucretius' argument (ii 478ff). Lucretius supposes that the shape of an atom is determined by the arrangement of its 'smallest parts'. He argues that the number of ways in which the smallest parts can be arranged is limited. Once this limit has been reached, a further variation in shape will require an increase in the number of parts, so that an infinite variation in shape will require an infinite increase in size.

In this form, Lucretius' argument cannot have applied to Democritus himself. For, as we have seen already, the notion of smallest or minimal 'parts' to an atom was an innovation by Epicurus.² Nonetheless it seems to me very possible that the argument which we find in Lucretius tells us by what process of thought the writer arrived at his conclusion in the *Placita*.

If that is so, then by a significant paradox we may see in Lucretius' argument both the reason why Democritus was thought to believe in 'very large atoms' and proof that this 'reason' is unhistorical. Democritus' belief in an infinite variety of shapes was thought to entail an infinite increase in size, but that entailment, at least in the form in which it appears in Lucretius, would be true only for the Epicurean notion of an atom that has parts.

Error Ancient and Modern

(i)

It is important to realise that the process I have described leads, not to truth, but to error.

¹Epicurus, *Ep. ad Her.* 55–6. Lucretius ii 498. Epicurus, later in his argument (cap. 56–9), and Lucretius (ii 482) do also write against the possibility of an 'infinite' increase of size. My point is that Lucretius is alone in providing the middle stage, as it were: the atom neither invisibly small, nor 'infinitely large', but 'hugely large'—*immani maximitate*.

² For the question of the 'parts' of atoms, see above pp.213–14 and 270–9.

The argument that infinite variation in shape leads to infinite variation in size appears not in Epicurus, but in Lucretius. Furley, for example, is wrong to attribute this conjunction of ideas to Epicurus himself, unless of course we are to attribute to Epicurus anything and everything that is said by Lucretius.¹

It is therefore quite wrong to suppose, as is frequently done, (1) that Epicurus himself argues that infinite differences in shape will require infinite differences in size (an unthinking conflation of the passages that I have quoted), (2) that the target of his criticism must be Democritus (in itself a possible, but not a necessary, premiss), and (3) that therefore Democritus must have believed in atoms 'very large' or even 'infinite' in size (an impossible conclusion, since it flatly contradicts the evidence in Aristotle).

For example, some such concatenation of ideas seems to have inspired Kirk's observation:

'Epicurus maintained that *infinite* shapes will eventually demand infinite sizes, and indeed Democritus may have suggested that some atoms are comparatively large.'²

The argument which Kirk has quoted is used, not by Epicurus, but by Lucretius. In Lucretius, the conclusion is not that some atoms are 'comparatively large', but that there would have to be an atom *immani maximitate* (ii 498) or even 'infinitely' large (*cf* ii

¹ *Two studies* 96 (citing *Ep. ad Her.* 55 and Lucretius ii 481–521); *cf.* p. 186 n.1 above. The same conjunction of ideas, but without explicit mention of the 'parts' of atoms, does seem to appear in a rather obscurely worded scholion, attached to the end of *Ep. ad Her.* 42. It is possibly his recollection of this scholion which has encouraged Furley to read the same idea into the later passage. In fact, in the later passage (cap. 55–6), Epicurus claims only that 'the existence of every size among the atoms is not needed for <an explanation of> the differences in quality'. This expression has apparently been read as meaning 'for an explanation of the infinite variety of shapes in the atoms'. But it can as well, and more naturally, be taken to mean that 'every size' of atom is not needed to explain the qualitative differences of sensible objects.

There is a detailed study of the scholion and its meaning by E. Bignone, 'Epicurea', *Atti della r. Accademia delle scienze di Torino* 47 (1911–12) 670–90, esp. 680–90. Before the passage was recognised as a scholion, the ideas that we now find in this scholion and in Lucretius were freely attributed to Epicurus, for example by Pierre Gassendi, *Animadversiones* 3rd edn (Lugduni, 1675) 113–14, *cf.* 217. But this hardly excuses the appearance of the same error in more recent authors.

² *Presocratic philosophers* 408 n.1.

482: *infinito . . . corporis auctu*). This conclusion is excluded, for Democritus, by Aristotle's assertion that Democritus' atoms are 'so tiny that they fall wholly below the level of our perception'.

(ii)

But the modern error repays closer inspection. In seeking to endorse the idea of 'very large' atoms for Democritus, Bailey writes:

'Logically of course infinite differences in shape imply infinite differences in size: for within the limits of the same size there can only be limited differences of shape, and further variety of form cannot be obtained except by increase in bulk.'¹

I do not myself see that this is so. Any shape, it seems to me, could in principle as well be embodied in a larger as in a smaller atom. Variation in shape, therefore, could take place without any alteration in size.

From the references which he gives, it is indeed fairly plain that Bailey thinks as he does only because he has made his own the conclusion of the argument in Lucretius.² But Lucretius' argument derives what cogency it may have from the supposition that the shape of an atom is determined by the various collocations of minimal 'parts'. If we do not think of the shape of an atom as being produced in this way, then there is no reason, it seems to me, why any shape should not theoretically be produced in a larger as in a smaller atom: nor any reason therefore why a single size of atom should not exist in any shape.

The truth, I suspect, is that Bailey's argument at this point illustrates the principle I outlined in my Introduction: the modern critic selects the evidence which is historically the weaker, because it reflects the prejudice of which he is himself the victim.³

In this instance, Bailey fails even to mention (at this point in his argument) Aristotle's repeated assertion that Democritus' atoms were too small to be perceived, and chooses to believe instead the

¹ *Greek Atomists* 125–8, esp. 127, cf. 77–82.

² See especially *Greek Atomists* 127 n.4.

³ Pp.xvi–xvii above.

evidence in Diogenes, Aetius and Dionysius, that Democritus thought there were, or could be, atoms 'infinite in size' or at least 'as large as a cosmos' or 'very large'.¹

Bailey chooses to ignore Aristotle, and to believe the later doxographical accounts, because the argument culled from Lucretius, that infinite variations in shape require an infinite increase in size, seems to him logically obvious (*cf.* 'logically of course . . .'). And yet this argument is most likely the very argument which has contaminated the later doxographical writers, and which has led them, as it has led Bailey, to the conclusion that Democritus believed in very large atoms.

Thus Bailey finds evidence to support his conclusion, but fails to recognise that the evidence which he finds conceptually appealing can have very little claim to historical truth. For not only does the conclusion of the later doxographical writers conflict with the evidence in Aristotle. Bailey fails to recognise that Lucretius' argument turns on the idea that the atoms have 'parts', and that this idea at once deprives Lucretius' reasoning of any immediate relevance to Democritus, since, as Bailey himself recognises, Democritus' atoms were without parts.²

(iii)

I have singled out Bailey's interpretation, although the presuppositions which it betrays are hardly less blatant in a number of other accounts.

Thus although Sambursky claims to be writing as a physicist and not as an historian, he is no less confident than Bailey when it comes to linking variation in shape to variation of size.

'This difference', between Epicurus and Democritus on whether the number of shapes is finite or infinite, 'follows naturally from a variance in the assumptions about the size of the atoms. To every given size it is possible to assign only

¹ Atoms 'infinite in size', Diog. Laert, ix 44 (DK 68A1). 'An atom as large as a cosmos', Aet. i 12.6 (DK 68A47). 'Very large atoms', Dionysius *ap. Eus. Praep. evang.* xiv 23.3 (DK 68A43). Contrast Aristotle, *De gen. et corr.* i8, 325a30 (DK 67A7), *ap. Simpl. De caelo* 295.6 (fr. 208 Rose = DK 68A37).

² Bailey recognises, *Epicurus* 203, that the 'parts' of atoms were an innovation by Epicurus.

a finite number of distinctly different shapes, and once all the possible mutations have been exhausted, a fresh shape can only come into being through an increase in the volume of the atom.¹

Although this is again offered as a self-evident truth (*cf.* 'follows naturally'), with no reference to the 'parts' of atoms, and with no immediate acknowledgment of Lucretius, nonetheless one is not surprised to find, a few lines later on the same page, that:

'Lucretius . . . gives an extremely vivid illustration of how the increasing number of shapes is linked with the increasing size of the atoms.'

Sambursky does not appear to appreciate that the 'parts' of atoms in Lucretius are not merely a 'vivid illustration' of the argument; without them, or so it seems to me, the principle which Sambursky puts forward so confidently has no validity at all.

(iv)

I conclude that the error in the Greek doxographers has probably arisen from the very phenomenon which we can ourselves now witness, with varying degrees of directness, in the pages of our modern doxographies, *The Presocratic Philosophers*, *The Greek Atomists* and *The physical world of the Greeks*.

The ancient and the modern critic have alike accepted the argument which appears in Lucretius, that an infinite variation in shape requires an infinite increase in size. The premiss of the argument—the 'parts' of atoms—is silently discarded. Democritus, it is then assumed, since he believed in an infinite variety of shapes, must therefore have believed in atoms that were infinitely large.

Thus the modern critic finds ancient evidence to support him, but only because he appeals to precisely those writers of the ancient world who share his own prejudice, and who repeat his own error.

¹ *The physical world of the Greeks* 111, *cf.* p.v.

The principle which we find so clearly exemplified in the grotesque conclusion that Democritus believed in atoms 'as large as a cosmos': will this same principle perhaps prove to be true for the idea that Democritus' atoms are deprived of weight, since they fail to 'fall' in an endless void?

Conclusion

(i)

We have the interesting position that the idea of an atom 'as big as a cosmos' derives either from a direct simplification of the original theory, or from a misguided attempt to mark more clearly the distinction between the earlier and the later atomic theory, or perhaps most probably from applying the Epicurean conception of an atom, with minimal 'parts', to the original Democritean conception of an atom, and adding to this the later argument that infinite variations in shape require infinite variations in size.

(ii)

In Alexander we found a similar occasion of error. Alexander questioned whether the atom could have weight, on the ground that the logically distinguishable 'parts' of the atoms did not have weight, while tacitly compounding this error, or so it would appear from the sequence of his argument, with the later principle that natural movement is caused by weight, so that if a body has no natural movement downwards it will have no weight.¹

Thus we have a very similar circumstance in Aetius and in Alexander.

1. In Aetius, if my suggestion is correct, the atoms are thought to have parts and therefore to have infinite variations in size.

2. In Alexander, the atoms again have parts and are therefore argued to be lacking in weight.

¹ Alexander, *Met.* 36.21–8 (in part DK 87A6); see ch.VII §§ 3–4, pp.211–22 above.

(iii)

Is it then coincidence that in Aetius the erroneous idea of 'a world-sized atom', an idea derived, or so it would seem, from the notion of an atom having 'parts', stands cheek by jowl with the only other explicit denial in ancient literature that the atoms have weight, apart from the denial by Alexander, which is again derived from the historically erroneous notion that the atoms of Democritus have 'parts'?

A piece of evidence cannot necessarily be condemned by the company it keeps. Nonetheless, this proximity can only encourage the conclusion that the denial of weight by Aetius is likewise the result of applying the Epicurean and Aristotelean conception which we find, or which we appear to find, in Alexander, the notion of weight as cause of movement downwards, to the original Democritean conception of atomic movement, where weight was not necessarily tied to the notion of a fall of atoms.

§ 5—

Aetius' Dependence on Theophrastus

The second guiding truth to an interpretation of the *Placita*, which has been brilliantly established by Diels (who is one of the very few modern scholars in the field of Presocratic philosophy to whose work one can properly apply that adverb), is that the great bulk of material on the philosophers of the fifth century derives from successive abridgments of Theophrastus' great history.

The particular relevance of this second truth to our enquiry is that it sets Aetius in clear opposition to Simplicius, not only conceptually but doxographically.¹

¹ Diels' conclusions on the origins of the *Placita*, though often ignored (for example by Mugler, *cf.* pp.286–7 above), have not, I think, been seriously challenged. Unfortunately, however, on the question of dependence—as distinct from the possibility of 'gross error'—Diels' thesis, from the nature of the case, does not lend itself to corroboration by the study of a single instance. For what is at issue is the general provenance of materials in the *Placita*, and I would not of course deny that especially on more technical questions, and on points of detail, there has been some interpolation of information from other sources: the possible influence of Eudemos, for example, is taken some account of in my study, 'Derived light and eclipses in the fifth century', *JHS* 88 (1968) 114–127, esp. 114–15. Important therefore though it is for my present thesis that Aetius' information should in general be taken from Theophrastus, nonetheless I have

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(i)

Very briefly, I rehearse the main points of the problem as my argument has sought to establish them so far.

The position initially is that Theophrastus, Aristotle and Simplicius attribute weight to the atoms. Aetius, in a single entry, denies that the atoms have weight.

Burnet and others attempt to resolve this conflict, by proposing that we limit the attribution of weight to atoms within a cosmos, leaving the denial of weight by Aetius to be true for atoms that are outside a cosmos.

We need therefore to look at the evidence, from this point of view.

1. Aetius could be speaking only of atoms that lie outside a cosmos, since the denial of weight is followed by an account of the atoms' movement ἐν τῷ ἀπείρῳ.
2. Theophrastus and Aristotle do not specify expressly whether the atoms have weight only within a cosmos.

However, they do not leave any obvious opening for such a qualification, and on the whole the form and the content of their remarks appear to preclude it.

3. Simplicius, expressly and by implication, attributes weight to atoms which are outside a cosmos: by implication, when he ties the weight of atoms to their hardness and to the uniformity of their nature; expressly, when he writes of atoms moving through the void 'in accordance with their weight'.

Thus *conceptually* Simplicius is directly opposed to the entry in Aetius, as glossed by Burnet.

(ii)

The point which I now wish to make is that Simplicius is no less opposed to Aetius on *doxographical* grounds.

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had to leave this point to rest on the authority of Diels, and on the very considerable amount of material which he has collected and analysed in his edition of the Greek doxographers.

Simplicius lets it be clearly seen, in the *De anima*, that he does not have any original writings from Democritus or Leucippus.

On the other hand, in the *De caelo*, he quotes once at length from Aristotle's lost work on Democritus, while in the *Physics* he quotes several times from portions, otherwise unknown to us, of Theophrastus' account of the first principles of the physical philosophers, including a longish extract on Leucippus and Democritus.¹

There are therefore two questions which we may ask of Simplicius.

In attributing weight to the atoms, and specifically to atoms which are outside a cosmos, is Simplicius possibly recalling some lost portion of Aristotle's work on Democritus or of Theophrastus' *Physicorum opiniones*?

Alternatively, is Simplicius doing no more than himself joining together passages where Aristotle says that the atoms have weight with passages where Aristotle and Theophrastus say that the atoms are solid and have all the same nature, or perhaps even explaining simply in his own terms how it is that the atoms move in the void without an extrinsic moving cause?

Now while it may conceivably be possible to distinguish between one or other of these alternatives with some show of reason, inevitably the choice will be speculative and perhaps even to a certain extent subjective.

¹ *De caelo* 294.33–295.20 (fr. 208 Rose = DK 68A37). *Phys.* 28.4–27 (*Dox.*, *Phys. op.* fr. 8 = DK 67A8 and 68A38). Other fragments quoted by Simplicius from Theophrastus' *Physicorum opiniones* are collected by Diels, *Dox.* 473–95.

It should be noted that I do not say how much of Aristotle's work on Democritus or of Theophrastus' *Physicorum opiniones* was available to Simplicius: but it seems to me reasonably clear that Simplicius knew more than we do of these works, and it is this that determines the form of my argument. In particular, Simplicius probably shows that he quotes only a part of the text that he had before him of Aristotle's work on Democritus when he writes, *De caelo* 294.33–295.1 (DK 68A37):

ὀλίγα δὲ ἐκ τῶν Ἀριστοτέλους περὶ Δημοκρίτου παραγρα-φέντα δηλώσει τὴν τῶν ἀνδρῶν ἐκείνων διάνοιαν. A later scholar—Tzetzes, for instance—might add this kind of detail simply to try to show that he knew more than he did; but Simplicius is quite above that kind of subterfuge.

It is essential to appreciate therefore that *even if* we can answer affirmatively only to the second question, this answer is not without its value.

For *even if* the attribution of weight to the precosmic atoms is Simplicius' own conclusion, at least it indicates that neither in Theophrastus nor in Aristotle had Simplicius found anything, or at least remembered anything, to controvert such a conjunction of ideas by limiting the weight of atoms to their behaviour within a cosmos.

Thus Simplicius is opposed to Aetius not only conceptually, but doxographically as well.¹

Conclusion

It is, I think, on this ground that the denial of weight to the atoms by Aetius finally loses whatever shreds of probability it may have retained hitherto.

Simplicius' attribution of weight to the atoms shows at least that he has found, or remembered, no restriction by Theophrastus or by Aristotle on the attribution of atomic weight to atoms that form part of a cosmos.

But Theophrastus would have been by far the likeliest source of such information in Aetius, if it had been true.

¹ The argument will be more cogent if we believe, as I do, that Steinmetz, *Die Physik des Theophrastos* 338–46, is right, as against Diels, *Dox.* 112–13, in arguing that Simplicius' quotations are not derived from Alexander, but are taken directly from Theophrastus, or at least—so Steinmetz argues—from a handbook containing excerpts from Theophrastus (a possible, even probable distinction, but one which is much more difficult to establish than Steinmetz appears to suppose). This had also been the conclusion of Karl Reinhardt, *Parmenides und die Geschichte der griechischen Philosophie* (Bonn, 1916) 92 n.1, and of O. Regenbogen, 'Theophrastos', *Real-Encyclopädie Supplementband vii* (1940) 1536.

On the other hand, Steinmetz's thesis slightly loosens my argument, since he supposes that Aetius' excerpts represent a version of Theophrastus' earlier work, the *Physicorum opiniones*, in its middle state as it were, when it had already been put together from a number of monographs, while Simplicius' quotations, he supposes, derive from Theophrastus' own later work on *Physics*.

This part of Steinmetz's thesis seems to me rather tenuous (*cf.* p.4 n.1 above): but in any case the origins of Simplicius' information and of that in Aetius would still be sufficiently close for the purpose of my argument, since Steinmetz allows that the doxographical portions of Theophrastus' own work on *Physics* will be re-written from the earlier, more purely doxographical work.

Thus not only do we have Theophrastus' own account of Democritus' theory of weight from the portion of his history dealing with the senses and the objects of sense, where there is no hint of any such qualification, and where indeed any such qualification would seem, at least by implication, to be excluded. On a proper reading of the evidence, we have a reasonable guarantee from Simplicius that no such qualification was contained in those parts of Theophrastus which are lost to us but which were still available to Simplicius.

We must therefore, I think, have recourse to the explanation of error which already lies so easily to hand.

Only one other ancient writer denies, or at least questions, the attribution of weight to the atoms. The reasons for which Alexander does so are demonstrably false. It is significant nonetheless that he is fairly clearly led to his conclusion, in part because he finds an inconsistency between the possession of weight and the absence of a 'fall' of atoms.

Most likely the writer in the *Placita* has fallen into the same trap.

1. The atoms move by recoil in the void, and therefore at random.
2. The atoms have no single downward movement, therefore.
3. Therefore, it is supposed, they can have no weight.

The claim that the atoms 'have no weight' will be as valueless as the grotesque assertion, in the same entry, that Democritus thought there could be an atom 'as large as a cosmos'.

Chapter Eleven— Indirect Evidence

§ 1— Aristotle 'On Democritus'

(i)

At this point, I should perhaps conclude the argumentative part of my study directly, for all the obvious sources have been ransacked, and the argument, such as it is, has a certain conceptual simplicity, which any further and more speculative considerations may serve only to blur and to weaken.

However, to do so would not be altogether honest.

In argument, there is often a temptation to deploy only those factors which, one hopes, will stand up well to criticism, even though they may not in fact have been the most fertile influences on the formation of one's conviction or opinion.

So it is in this case. There remains one piece of evidence which a sceptical opponent could easily dismiss, but which I find myself, at least in the light of the more formal argument which has preceded, particularly persuasive.

(ii)

So far I have said scarcely anything of Aristotle's work on Democritus, other than that a fairly lengthy extract from it is copied out by Simplicius.

This extract, however, deals precisely with the nature and behaviour of the atoms, and the manner of their movement in the void. Clearly, this is precisely the kind of context which would have provided Simplicius with his notion of atoms moving in the void 'according to weight', if that conjunction of ideas is not wholly the product of his own reflection.

Needless to say, there is no specific mention of weight in the extract which Simplicius quotes.¹ If there had been, the extract

¹ Contrast Cherniss, *ACP* 211 n.253, *cf.* p.17 n.1 above.

would have been given pride of place in our earlier analysis. But I think it possible that the notion of weight, and even of movement in some way 'according to weight', is in fact implicit in the following lines, and was perhaps known to be so by Simplicius.

De caelo 294.33–295.24 (fr. 208 Rose = DK 68A37): Δημόκριτον ἀλλοίωσις ἂν εἴη ἢ γένεσις.

"The transcription of a few sentences from Aristotle's treatise *On Democritus* will give us an idea of how these people thought.

"Democritus considers that the identity of things everlasting is such as to make them tiny substances, infinite in number, and he then supposes <that> for these <substances is needed> a place, other <than themselves>, which is infinite in extent. . . .

"These substances he reckons are so tiny that they fall wholly below the range of our sensible perceptions. They have all kinds of shapes and all kinds of figures and also differences in size.

"Objects which we can and do see, and <in general>

objects <or masses> which do fall within the range of our perceptions, are made up directly and without intermediary (*sc.* ἡδὴ) from the agglomerations of these substances, which <therefore> have the role of elements <in relation to the sensible objects which are formed from them>.

"The original substances are in movement in the void, they are at war, because of the unlikeness <between them> and because of the other differences <of shape and of size> already specified.

"As they move <about in the void> these tiny substances knock against <one another>, and get entangled <with one another> in such a way that their entanglement brings them into contact and keeps them close to one another They hang together, with one another, and stay together, he reckons, for however long it may take before some more powerful <influence or> necessity intervenes from the space around them, in such a way as to smash <the atoms> apart and scatter them in different directions."

'Democritus' description of how things come into existence, and of the separation that is the opposite of their coming into existence, covers not only <the production of> animals; it includes plants and <whole> worlds; in a word, it embraces all objects that are perceptible to sense.

'The lesson we may draw (τοίνυν): if the coming into being <of sensible objects> is <explained as> a conjunction of atoms, and if the destruction <of sensible objects> is explained as> their separation, then it would follow that coming into being, so far as Democritus is concerned, would be <reduced to what Aristotle would call> *alloiosis*, <and is not what we would recognise as properly a change of substance>'.¹

¹ I have taken the direct quotation from Aristotle to end at 295.20; the following paragraph in my paraphrase, 295.20–2, I have taken (perhaps arbitrarily) as most likely Simplicius' re-writing of what he found in Aristotle; the final paragraph of my paraphrase, 295.22–4, is Simplicius' own justification for his quotation. The interpretation that Simplicius has chosen of the atomic theory allows Democritus, no less than Empedocles, 295.24–6, to be enlisted against the

(footnote continued on next page)

Simplicius

(i)

It is perhaps Aristotle's preoccupation with a single and eternal world which has led him, it would seem, unlike the conventional doxographical sources which deal with Democritus, to run together every kind of generation and destruction, whether of worlds or of the individual entities which constitute a cosmos.

However, it is reasonably apparent, it seems to me, that the expression *στασιάζειν δὲ καὶ φέρεσθαι ἐν τῷ κενῷ* refers to movement outside a cosmos, not only because the reference to void is most simply taken as being to a non-cosmic void, but also because the movement described by the expression is fairly clearly intended to be at once distinct from and antecedent to the two kinds of movement that produce, respectively, generation and decay.

1. Of these the first is introduced in the clause immediately following: *φερομένας δὲ ... περιπλέκεσθαι περιπλοκὴν τοιαύτην κ.τ.λ.*

2. The latter is introduced in the sentence beginning: *ἐπὶ τοσοῦτον οὖν χρόνον κ.τ.λ.*

The two kinds of movement are then summarised by Simplicius as the pair *διάκρισις*.

(ii)

Now this is precisely the distinction which we have already seen adopted by Simplicius in his commentary on book eight of the *Physics*, where he speaks of the atoms as 'moving in accordance with their weight'.

(footnote continued from previous page)

<Christian> theory of a once-and-for-all destruction of the cosmos, 295.26–9.

I have departed from Heiberg's text on the following readings: *διαφοράς* (of size, 295.11).

1. There is the 'primary and only movement' which is local movement, and which is said to have been described by the Atomists themselves as περιπαλάσσεσθαι .
2. Subordinately to this there are the two forms of movement whereby the atoms are joined and separated, which are described by the same verb as in Simplicius' account of Aristotle, but with different prefixes, ἀποκρίνεσθαι .¹

(iii)

In Simplicius' own account, three factors are specified in relation to the primary movement of the atoms.

1. It takes place in the void.
2. It is described by a pair of terms, περιπαλάσσεσθαι .
3. It occurs 'according to weight': κατὰ τὴν ... βαρύτητα .

In Aristotle's account, there are also three factors relating to the primary movement of the atoms.

1. It takes place in the void.
2. It is described by a pair of terms, φέρεσθαι .
3. It occurs 'because of unlikeness and difference': διὰ τε τὴν ἀνομοιότητα καὶ τὰς ἄλλας εἰρημένους διαφοράς .

The *first* factor is identical to the two accounts.

The *second* factor is remarkably similar. In either case, there is what one might call a neutral expression for movement, περιπαλάσσεσθαι , which Simplicius specifies as a term taken from the original expression of the theory.²

¹ *Phys.* 1318.30–1319.5, above ch.V § 3, pp.166–73.

² For my defence and explanation of this reading see above pp.169–70.

(iv)

What of the *third* factor?

I have already suggested, from comparison with other contexts in Simplicius, that the prefix *περι* may be related to the question of weight. The atoms 'dart *around*', they 'leap *hither and thither*', because of the force of impact generated, or occasioned, by their weight.¹

Thus in Simplicius the third factor would appear to be related to the more idiosyncratic of the two expressions which fall within what I have called the second factor.

1. There is no particular association that springs to mind between movement expressed as *κινεῖσθαι* and the notion of weight, unless we associate weight with movement downwards, which I have argued is not Simplicius' intention here.
2. But the expression which Simplicius specifies as drawn from Democritus himself can be readily associated with weight, in the manner I have indicated.

There is a parallel association of the equivalent two terms in Aristotle.

1. There is little association that is immediately apparent between movement expressed conventionally, and colourlessly, as *φέρεισθαι* and the notions of unlikeness and difference.
2. There is an obvious connection, if only perhaps on a psychological plane, between unlikeness and difference and the much more idiosyncratic expression which Aristotle couples with *στασιάζειν*.

We have then in Simplicius and in Aristotle the following conjunction of ideas.

1. In Simplicius, it appears that the atoms 'dart hither and thither' or 'shoot this way and that' because of, or in accordance with, their weight.

¹ Pp.170–1 and 192–5 above.

2. In Aristotle's fragment on Democritus, the atoms are 'at war with one another' because of the 'unlikeness' and the 'differences' between them.

(v)

Among the differences that Aristotle has specified as causing, or accompanying, the 'war' of the atoms are differences of size (... καὶ κατὰ μέγεθος διαφοράς).

From passages elsewhere in Aristotle and in Theophrastus we know that in fact differences of size go hand in hand, for the Atomists, with differences in weight.

Does the general similarity of structure between the passage in Simplicius and Aristotle's fragment on Democritus, and in particular the similarity between the context and function of περιπαλάσσεσθαι in Simplicius?

Can we perhaps conclude, from the collation of these two passages, that the theoretical equivalence between size and weight was in fact intended as an element in the original theory of the movement and 'strife' of atoms in the void?

(vi)

One final hint possibly helps to indicate that we can.

I have said that περιπαλάσσεσθαι.

However, in the clause immediately following, στασιάζειν) 'attack' one another.

This notion takes us close to the idea of collision that I have suggested we may have in the collocation of κατὰ τὴν βαρύτητα in Simplicius.

The 'unlikeness' and the 'differences' of the atoms lead to

'strife' between them. In Aristotle's account is it perhaps also differences of weight, and not only differences of size, which determine the force of impact when the atoms 'fall upon' or 'attack' each other?

Conclusion

I noted in my earlier discussion of the passage from Simplicius' *Physics* that the phrase which is applied to the void, 'yielding and unresistant', is repeated in Plato's *Cratylus*. Plato's use of the expression would seem to confirm the antiquity of the material which Simplicius has here recorded.¹

This lends added authority to Simplicius' description of the atoms in the void as 'moving because of' or 'in accordance with their weight', and as 'darting hither and thither', περιπαλάσσεσθαι, a verb which Simplicius specifies as taken from the original expression of the theory.

Simplicius' account of the atoms' movement in this passage in the *Physics* is parallel in several ways to the account of the atomist theory which he records in the *De caelo* as taken from Aristotle's treatise 'On Democritus'.

Simplicius is not a mindless copyist. I could myself believe that the material which Simplicius records in the *Physics* is also taken from his reading of Aristotle's treatise 'On Democritus'. But that is only surmise. What remains significant is that the similarities between the two passages prompt the question—to use no stronger expression—whether when Aristotle writes of the atoms as 'attacking' one another (κατὰ τὴν ἐν αὐτοῖς βαρύτητα).

¹ Pp.167–8 above.

§ 2—

Movement and Difference

An affirmative answer to the same question is perhaps indicated—for I hope I have already stressed sufficiently that in this chapter we have to do with indications, and not with proofs—from quite another angle, if we take a broader, and admittedly still looser, view, whereby these sentences in Aristotle appear as part of a wide complex of passages, and of theories, which join unity with rest, and movement with plurality and variety or difference.

These passages I have already grouped in my study on Empedocles.¹ A couple of points—which I repeat are of a very general nature—are perhaps relevant to the present enquiry.

Earlier Thinkers**(i)**

If we consider this alignment and association of ideas among Democritus' more immediate predecessors, there is a wide spread in the kind of variety or difference with which movement is associated.

Thus for Parmenides (fr. 8.40–1) the antithesis to unity and rest is that things should 'come into being and pass away, exist and not exist, move about from place to place, and alter their bright colour'.

For Anaxagoras (fr. 4), the entities which will be released from the primal, and static, unity, are 'the damp and the dry, the hot and the cold, the shining and the dark, much earth, and seeds infinite in number, in no way like to one another'.

For Empedocles, the equivalent association of ideas is slightly complicated by his cyclical theory. The variety of elements which have been unfolded from the unity, and immobility, of the Sphere is emphasised: the sun which is bright and hot, water which is dark and shivering (fr. 21). However, the variety and multiplicity of the world's present existence does not represent a time of total

¹ *Empedocles' cosmic cycle, a reconstruction from the fragments and secondary sources*, in the series *Cambridge classical studies* (henceforward *ECC*) (Cambridge, 1969) 38–45.

separation. When the elements are fully divided by Strife, then sun, earth and sea are no longer visible in their present form. Even at the time of total Strife there remains, however, the collocation of movement and of separation. Each element 'goes its own way' with no admixture of any other.¹

(ii)

Anaxagoras and Empedocles retain the notion that much of the variety of sensible phenomena is ultimately real. Certainly, the most familiar traditional pairings of opposites, hot and cold, light and dark, dry and wet, belong to the elements, or are the elements.

In these theories, therefore, multiplicity is the same as diversity. The distinction between unity and plurality coincides with the distinction between uniformity and variety.

Not so for the Atomists. The atomic system is evidently designed to effect a drastic simplification of the variety of existence. Aristotle is right: the atoms have all a 'single' substance or 'nature', in the sense at least that the atoms are not specifically characterised by distinctions from the traditional pairings of opposites.² Hot and cold, wet and dry, light and dark, arise from the configurations of atoms (and, in a stricter sense, from their interaction with a sensible percipient), but none of the atoms possesses any of these characters intrinsically. The 'variety' of the atoms is primarily, and almost exclusively, a variety of shape and of size.

Thus in the atomic system there is an extreme *multiplicity*—indeed an infinity—of primary elements, but their *variety* is reduced to variations of shape and of size.

(iii)

It is the more interesting, therefore, that, if we believe Aristotle in the fragment 'On Democritus', then the Atomists still appar-

¹ Fr. 26a, with the accompanying paraphrase by Plutarch, *De facie* 926D-927A (only in part DK 31B27), quoted pp.369–70 below. On this feature of Empedocles' system, and for this distinction in the numeration of the fragments, see *ECC* 31–6 and 149–54.

² Arist. *De caelo* i 7, 275b32–276a1 (DK 67A19), quoted above pp.11–12.

ently wished to adopt the association of movement—which is probably also to a large extent an 'explanation' of movement—with 'differences' and 'unlikeness'.

If they did so, it would seem to me perhaps likely that they would employ the full range of variety allowed by their theory: and therefore that variations in size should entail, in this context, variations in weight.

Plato's 'Timaeus'

This same collocation, of movement with plurality and diversity, is a fairly prominent feature of the cosmogony, and cosmology, of the *Timaeus*.

On a mechanical level—if that is not too misleadingly modern an expression—Plato writes of the origins of rest and movement as resulting from the conjunction of moved and mover but on the ground that moved and mover can never be 'homogeneous' or 'alike' (57D-E). The prominence given to the distinction of moved and mover is perhaps specifically Platonic, but the concluding generalisation, that rest is dependent upon, or consequent upon, homogeneity, while movement somehow belongs to heterogeneity, is thoroughly traditional (cf. 57E6–58A1: οὕτω δὴ στάσιν μὲν ἐν ὁμαλότητι, κίνησιν δὲ εἰς ἀνωμαλότητα ἀεὶ τιθώμεν).

The two principles are repeated in several places in the *Timaeus*: in the account which Plato gives of two kinds of water, of which the more fluid and the more mobile kind is so because the elemental particles which it is made from are small and unequal in size, also because of 'the nature of its shape', while the other kind is more nearly static because of the uniformity of its components; and again in the account of shivering, which is caused by the struggle that arises when larger particles of water enter the body and effect a change 'from mobility and lack of uniformity to uniformity and immobility'.¹

On a more nearly cosmogonical level, the same principle is applied to the transformation of the elements. When the main cosmic masses are formed from the various combinations of the elemental triangles, and move each 'to their own proper place',

¹ *Tim.* 58D4–E7 (note esp. 58D7–8: ἀκίνητον δι' ὁμαλότητα).

they do so because 'they are unlike to each other, and like to something else'.¹

The earlier and more general statement of this circumstance specifies lack of 'balance' as a factor responsible for lack of uniformity, 52D4–E5:

μὲν ὕπ' ἐκείνων αὐτήν, κινουμένην δ' αὖ πάλιν ἐκεῖνα σείειν .

'The nurse of becoming grows wet and fiery, takes up impressions of earth and air . . . is many a different kind of sight to see.

'But since the powers it is filled with are not of the same kind, and are not equally balanced <in weight> therefore there is no balance in any part of it; on the contrary, swayed unevenly on every side, the nurse of becoming is shaken by the powers <that fill it> and by taking up <their> movement shakes them in return.'²

Conclusion

The text of Aristotle's fragment on Democritus does not speak explicitly of weight. On the other hand, the context is precisely of the kind where we might expect to find a place for the inclusion of weight as determining the movement of atoms in the void, if that conjunction of ideas is not solely the product of Simplicius' own imaginings. In fact, comparison with Simplicius indicates that the

¹ *Tim.* 57B7–C6.

² I justify taking these two passages together (52D4–E5 and 57B7–C6) in my second essay. I have taken ἰσορροπεῖν . See further p.363 n.1 below.

'strife' of atoms which Aristotle associates with the unlikeness and diversity of their shapes and with their differences of size may equally be associated with differences of weight, and perhaps in particular that the atoms' force of impact is determined by their weight.

At the same time, there is in the fifth century a tradition of unity and uniformity being associated with rest, and of movement leading to, or stemming from, plurality and diversity. If, as appears from Aristotle, the Atomists intended to associate themselves with this tradition, then it may be thought likely for them to have added weight to size and shape as the only ultimate factors of diversity which their system leaves room for.

The same association, of rest with unity and uniformity, and of movement with plurality and diversity, is a significant feature of Plato's *Timaeus*. In the *Timaeus*, the diversity that is associated with movement, and more particularly with movement on a cosmogonical level, is in fact specified as diversity of size and of 'balance' or weight.

§ 3—

Aristotle 'Physics': Speed and Weight

Aristotle's fragment on Democritus has one further use, in enabling us to gain a more precise knowledge of the background and implications of the passage which I touched on earlier from the fourth book of Aristotle's *Physics*.

Aristotle's argument is there directed against the notion of movement in a void. Earlier I left it an open question whether or not the means by which Aristotle argues against this idea were drawn solely from his own reflections and theories, or were perhaps related to original features in the atomic theory of movement. To this question I now return.¹

¹*Phys.* iv 8, 215a25–9 and 216a11–21, pp.187–9 and 190–2 above. I have already noted that Aristotle's arguments are not directed exclusively against the Atomists. Democritus and Leucippus are introduced as the target of Aristotle's criticism at the beginning of his analysis, but in company with 'many other of the physical philosophers' (iv 6, 213a34–b1, *cf.* p.189 above).

Shape, Size and Weight

(i)

Aristotle's aim is to conclude that in a void bodies of different weight would have to move all with the same speed. This is taken as sufficient refutation of the possibility of movement in a void.

Aristotle argues that there are two reasons for differences of speed: differences in the resistance of a medium and differences of weight in the body moved.

Aristotle first argues, at length, that a void cannot provide for different levels of resistance, and therefore, by a favourite turn of argument, that movement in a void would be, in various ways, infinitely incommensurable with movement in a medium.

Aristotle then turns to differences within the body moved, in order to argue, much more briefly, that none of the factors which might, or which do, produce different speeds of movement in a material medium could have the same effect in a void.

However, instead of limiting himself to weight, which earlier had twice been specified as the factor which would be likely to lead to differences of speed, Aristotle in fact writes of weight, of size, and of shape, iv 8,216a18–20:.. ἢν ἔχει τὸ φερόμενον ἢ τὸ ἀφεθέν

'A larger body divides <the medium through which it passes> more quickly by <virtue of its greater> force: for it divides <the medium> either by its shape or by the weight <and impetus> which the body possesses when it moves or is released.'

(ii)

Shape, size and weight are precisely the three factors that we have recovered from Simplicius and from the fragment on Democritus.

1. Shape and size are the two factors which accompany movement in Aristotle's fragment on Democritus.
2. Weight, as we have seen, is added by Simplicius.

These same three factors Aristotle himself believes account for differences of speed within a material medium. All three recur in the *De caelo*.

1. As I noted earlier, a larger portion of an element moves more quickly to its natural place than does a smaller portion, and is therefore heavier or lighter, according to whether the movement is towards the centre or towards the circumference.¹
2. In the final chapter, Aristotle explains his own theory of the effect that shape has upon speed, which—possibly significantly—he sets in opposition to a theory of Democritus (cap. 6, 313a14–15: *ἑαυτοῦ ἢ βραδύτερον*).

It is because all three factors recur in Aristotle's own theory, and more particularly because in Aristotle's own theory weight and size are commensurate at this point, that from the form of argument in the *Physics*, taken alone, we cannot tell directly whether the mechanism of Aristotle's argument is intended to have any particular relevance to the theories of Democritus.

But what we now know, from the fragment on Democritus, is that of the three factors which in the *Physics* Aristotle says *cannot* explain differences of speed for bodies moving in the void, two *do in fact* in some sense belong to Democritus' theory of the movement of atoms in the void, namely differences of *shape* and of *size*.

Can we perhaps infer from this that the *third* factor in explaining differences of speed, namely differences in *weight*, may also perhaps be taken from Democritus' theory?

'De Anima'

A passage elsewhere possibly helps to indicate that we can.

(i)

Shape and size are specified as causes of mobility in Aristotle's

¹Notably *De caelo* i 8, 277a27–9, and iv 4, 311a18–21: a complete list of passages is given in my third essay. Aristotle's use of speed as a criterion of weight has already been noted, p. 54 n.1, and is explored in my third essay.

account in the *De anima* of the atoms which, for Democritus, constitute mind and soul, i 2, 405a8–13 (DK 68A101): τε νοῦν καὶ τὸ πῦρ .

'Democritus' utterance was more profound. . . . Soul he claimed was the same as mind, and soul or mind he claimed was one of the primary and indivisible bodies, an especially mobile one thanks to its smallness and to its shape. His argument is that what is spherical is the most mobile shape, and that <the atoms of> mind and fire are this shape.'

It would be precipitate, I think, to argue directly from this passage in the *De anima* to the calculation of Aristotle's methods in the *Physics*, since the *Physics* deals with movement in the void, including therefore, one might suppose, void which is outside a cosmos, while the *De anima* deals with movement within the cosmos.

With the mediation of the fragment on Democritus, I think that we have some right to bridge this gap. For the fragment on Democritus establishes that the two factors which lend soul its especial mobility, namely size and shape, are the same two factors which accompany, or even in some sense explain, the movement of atoms outside the cosmos.

(ii)

However, there is a further distinction between the *De anima* and the fragment on Democritus which is potentially significant.

1. In the fragment on Democritus, it is differences of size and of shape which lead to, or accompany, movement.
2. In the *De anima*, it is a specific shape and a specific size which are intended to lend the atoms which constitute soul an especial mobility.

However, this distinction is not, I think, enough to disallow the

conclusion that the explanation of movement in the *De anima* can be carried over to the movement of atoms which are outside a cosmos.

On the contrary, this distinction perhaps serves, on reflection, to increase the possibility that the mechanism of Aristotle's argument in the *Physics* coincides with Democritus' own theories.

For the general inference from the distinction is presumably that differences of size and of shape account for movement in general, while certain sizes, and certain shapes, of atoms are especially mobile.

What we have therefore in the *De anima*, which we do not have in the fragment on Democritus, is the idea that shape and size not only accompany movement, but are related to variations in mobility.

And that is very nearly the idea which Aristotle employs in the argument of the *Physics*: differences of shape and differences of size should cause differences of speed, but in the void—according to Aristotle—they cannot do so.

'Bitter' and 'Sweet' in Theophrastus' 'De Sensibus'

A passage in Theophrastus' *De sensibus* possibly takes us a step further in this same direction.

For in Democritus' theory of bitter and sweet, the shape and the size of atoms are associated not simply with movement, nor even with variations in mobility, but specifically with differences in speed.

(i)

I return for a moment to the mobility of soul.

The reason, or one reason, why a spherical atom is *λοιπὰ, κινούμενα καὶ αὐτά* .

'Of these atoms the spherical shaped ones he says are soul, because shapes of this kind are best able to dodge in and out

through anything else, and are best able to move other things, being in movement themselves.¹

Presumably something of the same reasoning will apply to size. The small, round atoms that constitute soul can dart in and out among, or perhaps even through, conglomerations of other atoms, making their way through gaps that would be too small for larger atoms, while at the same time they are free from the hooks and projections that would delay the passage of other shapes of atoms.

(ii)

Essentially these same ideas recur in the account in Theophrastus of atoms which cause a bitter taste.

These atoms too, like the round atoms which constitute soul, are able 'to insinuate themselves everywhere': διὰ παντός δύνασθαι διαδύνειν, of the atoms which constitute soul in the *De anima*.

The difference is that the atoms which cause a bitter taste are small, like the atoms which constitute soul, but instead of being round they are sharp or angular.

Presumably therefore the idea is that instead of managing to slide in and out between other atoms, or other agglomerations of atoms, as do the round atoms, these angular atoms force their way through things, through the human body, or if perhaps in the void through the whirling masses of atoms, by cutting a passage with their edges.

The point which is especially relevant to our purpose is that in this instance the movement of atoms, consequent upon their size and shape, is specified as being 'fast', *De sens.* 65 (DK 68A 135): καὶ μικρὸν καὶ λεπτόν. διὰ γὰρ τὴν δριμύτητα ταχὺ καὶ πάντῃ διαδύεσθαι .

'A tart flavour he says is <equivalent to an atom that is> angular and twisted in shape, as well as being small and thin;

¹ Aristotle notes that *ῥυσμός* is Democritus' word for 'shape', *Met.* A 4, 985b15–19 (DK 67A6).

the 'sharpness' makes it able to edge its way quickly in and out of anywhere.'

(iii)

The converse idea applies to atoms which explain the sensation of sweetness.

We may suppose that it is because 'bitter' and 'sweet' are opposites that atoms which cause the sensation of sweetness must be the 'opposite' shape and size to atoms which cause the sensation of bitter. They are therefore round, instead of being angular, and they are 'not particularly small'.

It is presumably because these atoms are 'not particularly small' that the effect they produce is 'not a quick one', although at the same time it is presumably their roundness which still allows them to 'slip through things' (*ταράττειν, ὅτι διαδύνων πλανᾷ τὰ ἄλλα καὶ ὕγραίνει*).

'A sweet flavour is made out of round shapes, that are not particularly small, which is why . . . they do not get through all their work quickly. They do however have a disturbing effect on the other flavours, because as they slide through other things they stretch and liquefy them.'¹

Conclusion

(i)

The position then is this:

1. In the *Physics*, there are three factors which Aristotle says cannot explain differences of speed in the void: shape, size and weight.

¹ In the *De causis plantarum*, vi 1.6 (DK 68A129), there is a summary of Democritus' theory of flavours, and the atoms responsible for a sweet flavour are there described positively as *εὐμεγέθη*.

2. From the fragment on Democritus, we know that in the original theory two of these factors, shape and size, do accompany the movement of atoms in the void.
3. From the *De anima*, we learn that these same factors not only accompany the movement of atoms, but cause, or are associated with, differences in mobility.
4. Finally, from Theophrastus we discover that these same two factors were correlated specifically with differences of speed.

The passages in the *De anima* and in the *De sensibus* do not in themselves deal with non-cosmic movement, as do the passages in the fragment on Democritus and perhaps in the *Physics*. But the fragment on Democritus establishes that shape and size, the factors affecting or controlling variations of mobility and of speed in the *De anima* and in the *De sensibus*, are also in some way associated with movement of atoms in the void.

(ii)

From the argument in the *Physics*, and from the related argument in Epicurus, Zeller concluded that Democritus' atoms, in moving downwards in the void, did so with differences of speed.¹

I have already said that I think Zeller's critics were right to abandon the idea of a fall of atoms for Democritus.² I am not sure that they were right to abandon therefore, as they did, Zeller's use of the argument in the *Physics*, in its entirety.

Admittedly, from Aristotle's argument in the *Physics*, taken in isolation, we have no means of telling whether the principles which he employs are drawn solely from his own theories, or whether they may have some more particular relevance to the ideas of Democritus, whom Aristotle has included among the targets of his criticism.

It is only because we can discover from elsewhere that two of the factors included in Aristotle's argument, shape and size, were in fact employed by Democritus in his account of the behaviour

¹ Zeller, ZN 1088–9. Arist. *Phys.* iv 8, 215a25–9 and 216a11–21. Epicurus, *Ep. ad Her.* 61.

² Cf. pp. 163–4 and 261–2 above.

of atoms, including their behaviour in the void, and specifically including (though in another context) differences of mobility and of speed, that we may have some ground for suspicion—I am deliberately pitching the argumentative element in this proposal no higher—that the third factor in Aristotle's argument, namely weight, may also have been reckoned by Democritus as affecting the movement of atoms in the void, and perhaps more particularly as determining their speed.

§ 4— Speed and Size

(i)

I have been careful to dissociate myself from Zeller's use of the argument in Aristotle's *Physics*, and of the parallel passage in Epicurus, as direct evidence that Democritus used differences of weight in the atoms to explain differences in speed.¹

My reason, so far, has been that without the additional passages which I have cited from the fragment on Democritus, from the *De anima*, and from Theophrastus, there would be little ground for associating the mechanism of Aristotle's argument with Democritus' own theory. It is, I have argued, only because these other sources attribute shape and size as determinants of movement, and even of speed of movement, to Democritus, that we can have some ground for suspecting that the third element in Aristotle's argument, weight, may also possibly belong to Democritus.

There is an additional reason for caution. The alignment of speed or of mobility with size in the account of Democritus' atoms in the *De anima* and in Theophrastus is not the same as the alignment of speed with size and weight in Aristotle's argument in the *Physics*.

1. For Aristotle, the larger body, whether it is heavier or lighter, moves the faster.

2. But in Democritus' theory, according to Aristotle's report in the *De anima*, the atoms which constitute soul have an especial mobility, not because they are large but because they are small and round.

¹ Zeller, ZN 1088–9. Arist. *Phys.* iv 8, 215a25–9 and 216a11–21. Epicurus, *Ep. ad Her.* 61.

There is a similar alignment in Theophrastus' account of Democritus in the *De sensibus*. The smaller, angular atoms which produce the sensation of bitter act 'quickly', while the round but 'not particularly small' atoms which produce a sweet taste do not work quickly.

Therefore the form in which Aristotle presents his argument has evidently been cast in terms of his own kinetics, where a body is lighter or heavier, and so moves faster, if it is larger: a larger quantity of fire moves upwards more swiftly than a smaller quantity, and a larger quantity of earth falls more quickly than a smaller quantity.¹

(ii)

I pause therefore to take stock of the state of affairs so far.

1. Size, shape and weight are presented by Aristotle as factors which might be expected to, or which do, effect differences of speed, but which in a void, according to Aristotle, cannot do so. From a number of passages elsewhere we discover that size and shape were in fact associated by Democritus with the movement of atoms, even of atoms that are moving in the void; more specifically, Democritus even associated differences of size and shape with differences of speed, though whether still for atoms that are moving in the void we do not know.

From all this we might be tempted to suspect that the third factor in Aristotle's argument, namely weight, was also a feature of Democritus' original theory, and that the three factors were used by Democritus to explain a difference of speed for atoms that are moving in the void.

¹ This difference between Aristotle and Democritus hardly impinges on earlier discussions. Thus Alfieri, whose reconstruction I have already noted as close to my own, p. 154 n.1 above, unthinkingly assumes that '... la differenza di peso avrebbe fatto sì che gli atomi più pesanti sarebbero stati più veloci dei più leggeri' (*Atomos idea* 81). It is difficult not to suppose that Alfieri has unconsciously selected this alignment simply because it is the one that is familiar to him from his reading of Aristotle; although even for Alfieri's formula to be true of Aristotle we shall have to construe 'più leggeri' as meaning 'lighter' in a purely negative sense, i.e. 'less heavy'. See also p.326 n.1 below and p.328 n.1 below.

2. However, from these same passages we learn that for Democritus smaller atoms move more quickly, while in Aristotle's argument it is the larger body which moves faster, according to the provisions of Aristotle's own theory, as elaborated in the *De caelo*.

This consideration tends to undermine, if it does not wholly overthrow, any suggestion that the mechanism of Aristotle's argument is related specifically to the terms of Democritus' own theory.

Faced with this *second* consideration, we might well be inclined to wash our hands altogether of any proposal to read back genuine elements in Democritus' theory from an argument in Aristotle which is demonstrably cast in terms of Aristotle's own principles.

I have nonetheless ventured to include the argument in the *Physics* as part of a network of evidence centring on the account of Democritus preserved by Simplicius from Aristotle, because there is a further angle from which we can approach the proposal that I have outlined in the preceding section; and this I think feeds back, as it were, into the proposal some of the substance that is necessarily drained from it by the consideration that the manner in which size, weight and speed are aligned in Aristotle's argument cannot be the same as the manner in which they would have been aligned by Democritus himself.

(iii)

In the first place, it is interesting to discover that Epicurus takes account of both alignments. Heavy atoms do not move any faster than atoms which are small and light, nor do small atoms move any faster than large ones, *Ep. ad Her.*, 61: *κούφων ... οὔτε τὰ μικρὰ τῶν μεγάλων*.¹

The denial of the former possibility, the alignment of large and fast atoms, makes it impossible to take Epicurus' criticism, in the

¹ This passage is quoted more fully pp. 184–5 above. For the subject of the sentence ('atoms' or 'bodies in general') see pp.159-60 above.

way that Zeller does, as orientated specifically and exclusively against Democritus.

But are the two possibilities possibly intended respectively as an answer to Aristotle and as a criticism of Democritus?

Or is the disjunction no more than a logical alternative, with no particular historical relevance?¹

(iv)

In the second place, there is evidence that the alternative alignment to that in Aristotle, namely of small and light and fast, as opposed to large and heavy and slow, did feature in pre-Aristotelean philosophy.

In the *Timaeus*, in a passage which I have already made use of,

¹ It is perhaps significant that only the Aristotelean half of this association, namely that the heavier <and therefore the larger> body moves the faster, appears in the equivalent argument in Lucretius, ii 225–9, quoted pp. 185–6 above.

A number of modern writers also attempt to exclude the non-Aristotelean association, by making Epicurus deny that small atoms move more slowly. Thus Usener writes, *Epicurea* (Lipsiae, 1887) 18: οὕτε τὰ μικρὰ <βραδύτερον>. Margherita I. Parente, *Opere di Epicuro* (Torino, 1974) 160–1, rejects Usener's emendation, but somehow manages to translate the second half of the sentence: '... né avverrà che ciò ch'è grande si muova più velocemente di ciò ch'è piccolo'. Usener's emendation (retained by Alfieri, *Atomisti* 104) produces a tautology; Parente's mistranslation makes the second sentence a useless repetition of the first.

Jean and Mayotte Bollack and Heinz Wismann, *La lettre d'Epicure* (Paris, 1971) 121 and 215–16, translate the second half of the sentence correctly, but then reintroduce the same supposition that we find in Usener and Parente when they write in their note that the phrase immediately following, πάντα πόρον σύμμετρον ἔχοντα, 'ne peut avoir d'autre fonction, en insistant sur la commodité offerte aux atomes petits, que de corriger indirectement l'idée que, dans l'invisible comme dans le visible, les corps légers tomberaient moins vite que les corps lourds'. The Aristotelean presupposition is here explicit.

The qualification contained in the phrase πάντα πόρον etc. is designed to correct will be that small atoms might move more quickly than large ones—just the opposite, therefore, of the Aristotelean supposition, introduced by M. and Mme Bollack and by M. Wismann, that small atoms would be expected to move more slowly.

Plato distinguishes two kinds of water, of which the more mobile kind is so because it is constituted from smaller elements, while the kind which is heavy and more nearly static is constituted from larger elements (58D4–E7).¹

Admittedly, the *Timaeus* is a two-edged sword when used as evidence for earlier physical theories. Plato's treatise—almost, in modern terms, a prose poem—is fairly obviously saturated with elements of Presocratic belief and terminology; but in the complete absence of any specific attribution it is impossible to tell, in contexts of this kind, whether any particular feature is drawn from earlier literature, or is Plato's own invention, unless we have some other external evidence.

(v)

Fortunately, in this case there is one other piece of evidence of precisely the kind that is needed.

The Platonic alignment, the idea that smaller <lighter> bodies move the faster, while larger and heavier bodies move more slowly, is in effect the alignment which Plutarch attributes generally to the first philosophers. In a passage from the *De primo frigido*, Plutarch tells us that in distinguishing heavenly and earthly elements the early philosophers divided what is *slow* (ταχέα καὶ κοῦφα).²

(vi)

We can then approach Democritus by a kind of pincer movement.

1. Aristotle employs size, shape and weight in his argument that the atoms would have to move in the void with differences of speed, which Aristotle holds would be impossible.

Democritus, we know, did associate differences of size and shape with the movement of atoms in the void, and did elsewhere associate differences of size and shape with differences of speed.

¹ Cf. pp.313–14 above.

² 955B–C: for the further use of this passage see below pp.366–72.

2. For Aristotle, the larger body will be heavier or lighter and in either case will move faster; for Democritus, smaller atoms move faster and larger atoms move more slowly.

However, the same alignment as in Democritus, but including weight, is rejected by Epicurus, recurs in Plato's *Timaeus* and is attributed generally to 'the first philosophers' by Plutarch.

Thus we do not have any direct attribution of the association of weight and speed to Democritus, nor can the mechanism of Aristotle's argument in the *Physics* apply to Democritus, directly in the form in which it appears in Aristotle.

But we do know that a large part of the mechanism of Aristotle's argument has particular relevance to Democritus' theory of movement, and in particular we do know that the realignment of associations that would be required if the mechanism of Aristotle's argument were to apply specifically to Democritus does correspond in fact to a general pre-Aristotelean and Presocratic belief that what is small and light moves quickly, while what is large and heavy is slow.¹

¹ One final piece of evidence should perhaps be mentioned here, namely Aristotle's criticism, in book four of the *De caelo*, of a theory whereby a body would be lighter in the sense only that it was either 'squeezed out' ἐκθλίβεται (references p. 153 n.3 above), from Plato, and from what he imagines to have been an Ionian theory of weight: from such a context, it is impossible to confirm or to deny the attribution of fresh detail to Democritus' theory, without independent evidence.

In his own theory, Aristotle does on occasion write of the 'smaller and lighter' body as the easier to move, *De caelo* iii 2, 301b1–16. But here 'lighter' is again used in a negative sense, and describes not the natural movement of an element, but movement that is the product of force: I return to this passage in my fourth essay.

Conclusion

The arguments of this section, as of the preceding sections in this chapter, are not demonstrative in a strict sense. They are allusive rather. The various considerations that have been advanced are convergent, but do not necessarily converge.

The text of Aristotle's fragment on Democritus does not speak explicitly of weight. It is a question therefore of trying to calculate the precise resonance and implication of the passage, in part by comparison with Simplicius' treatment of similar issues in a closely similar context, and in part by attempting to relate the passage to other texts from Aristotle himself, from the *Physics* and from the *De anima*, and also to texts from Theophrastus.

Comparison with Simplicius indicates that the 'strife' of atoms which Aristotle associated with the unlikeness and diversity of their shapes, and with their differences of size, may equally be associated with differences of weight, and perhaps in particular that the atoms' force of impact is determined by their weight.

Comparison with the *De anima*, where shape and size lend the atoms which constitute soul an especial mobility, and with Theophrastus' *De sensibus*, where shape and size are associated with differences of speed, possibly indicates that in the argument which Aristotle employs in the *Physics* against movement in the void weight, as well as size and shape, may be features taken from the original atomic theory of movement.

If Democritus has adopted the notion of atoms moving with different speeds in the void according to differences of size and weight, then his conception will have been that smaller, lighter atoms move the faster, while larger and heavier atoms move more slowly.

This is not the alignment which appears in Aristotle, but it is one of the alignments which is taken account of by Epicurus, and it is the alignment which Plato uses in the *Timaeus*, and which Plutarch attributes to the first philosophers generally.

Chapter Twelve— The Weight of Atoms

§ 1— The Minimal Conclusion

What then is to be our final judgment on the evidence?

It would be false, I think, to present a single and unqualified answer to the question which I asked in the opening chapter of this essay: whether, or in what sense, the atoms of Democritus, or of Democritus and Leucippus, have weight.¹ Qualification is needed, not only because criteria for the expression of weight need to be specified. There is also needed a stratification of the kind of likelihood that attaches to different elements in our answer.

A preliminary distinction is needed between the certainty that may attach to the analysis of various items of evidence taken singly and the degree of probability that may attach to any evaluation of the evidence as a whole. This distinction might have been less necessary, if any original text from Democritus had survived on the subject of weight. As it is, while I think that we can in fact be reasonably certain of the meaning, and of at least the immediate intention, of the main texts that I have analysed from Aristotle, from Theophrastus, and even from Simplicius, it does not follow that we can be certain in the same way about the original theory of Democritus to which those texts relate.

Although this distinction may seem plain enough when presented abstractly, in practice it is often, I find, blurred. If the text of a passage is reasonably secure, and if there is a wide enough range of context and allusion, then it seems to me that more often than not the immediate sense of the text can eventually be established beyond doubt, however difficult and controversial the establishment of its sense may prove to be in practice. It does not follow that the interrelation of texts, and their varying authority, can be made equally secure.

It is important not to allow legitimate doubt on this more general level to seep back into the analysis of individual texts. It is

¹ Cf. p.5 above.

equally important that one's certainty over the interpretation of particular texts should not spill over, and seek to establish, by its own momentum as it were, a more general certainty on the wider questions to which those texts relate.

Naturally, when faced with some seemingly impossible crux in the more general interpretation of some problem, one may expect the solution to be found, if at all, only through the reinterpretation of individual items of evidence. But in principle there is no reason why the meaning of individual texts should not be established beyond reasonable doubt, although their more general inter-relation and authority may remain obscure.

The danger is that legitimate doubt over some general crux of interpretation or of reconstruction can all too easily conspire with a desire to be, or at least to appear, if only to oneself, cautious and conservative, so that in effect one shrugs one's shoulders over a whole range of references to the problem, until even elements which in themselves may be decipherable are allowed to slip into the shadows of uncertainty.

On the other hand, a legitimate confidence over the interpretation of specific items of evidence may conspire with a more dubious sense of certainty about one's own intuitions into the intentions of a particular thinker, or into the nature of archaic thought, so that argument and analysis veer off into idiosyncrasy and dogmatism.

Either fault seems to me equally undesirable.

Thus in the present instance it seems to me that no reasonable doubt need attach to the meaning of the primary texts which I have analysed, from Aristotle, from Theophrastus, and even from Simplicius. But I do not attach the same level of certainty to our knowledge of the original atomic theory of weight to which these texts relate. The minimal position, it seems to me, which is compatible with the evidence, is that the atoms should have been endowed with differences of weight in virtue of their differences in size, but that no expression of their weight should have been specified, other than that of the distribution of atoms within a *dine*, and that of their attachment to the definition of lightness in terms of void.

Both expressions of weight, it can properly be argued, are in fact restricted to atoms within a cosmos, or within the beginnings of a cosmos.

1. In the cosmogony which he relates for Leucippus, which I touched upon in an earlier chapter, Diogenes writes of atoms 'whirling' in the void, but at the same time he makes it clear that the aggregation of atoms into 'a single *dine*' leads to the formation of a cosmos.¹

2. The definition of lightness in terms of void, since it applies to bodies compounded of atoms and the void, can again reasonably be argued to apply only to the behaviour of atoms within a cosmos.²

From this it follows that this preliminary, and minimal, conclusion to my argument coincides in its results with what I have called the current compromise. There is however the difference, and I shall claim in a moment it is a crucial difference, that I do not suppose that there can have been any express denial of weight for atoms that were outside a cosmos, since the existence of any such denial seems to me to be excluded, in particular by the texts that I have analysed from Theophrastus, and from Simplicius.³

For the moment, however, it is not this difference in content which I wish to emphasise, but the difference in argument and evidence.

In the study of Presocratic philosophy, the novelty of an interpretation is less important, it seems to me, than the reasons on which an interpretation is founded: the selection of evidence, its analysis and evaluation, and its incorporation into a general scheme of reconstruction and of interpretation.

I hope that it will not seem pedantic therefore to pause for a moment to insist that the reasoning behind even this preliminary conclusion is very different from that which lies behind what I have called the current compromise.

¹ix 30–1 (DK 67A1); ch.VII §§ 1–2, pp.203–11 above.

²Aristotle, *De caelo* iv 2, 308b28–309a18; ch.III, pp.80–114 above. Theophrastus, *De sens.* 61–2 (DK 68A135); ch.IV, pp.115–50 above.

³Theophrastus, *De sens.* 61–2 (DK 68A135); ch.IV, pp.115–50 above. Simplicius, *Phys.* 42.10–11 (DK 68A47), 1318.30–1319.5 (in part DK 68A58); *De caelo* 269.4–14 (not in DK), 569.5–9 (DK 68A61), 583.20–2 (DK 67A16), 712.27–31 (DK 68A61); ch.V and VI, pp.153–73 and 174–202 above.

(i)

In the first place, it seems to me unlikely in the extreme that the statement in Aetius, that the atoms have no weight, should be anything other than the product of doxographical confusion, in the kind of way that I have indicated.¹

To take the extreme case: even if the atoms of Democritus had in fact been stated explicitly in the original theory to be in certain circumstances without weight, or without the expression of weight, even so, it seems to me unlikely that the statement in Aetius would represent a genuine historical tradition, given the combination of the kind of context in which it appears, the lack of any sign of a similar statement in the texts which survive of Aristotle, of Theophrastus and of Simplicius, and the particular bearing which those texts must have on the origins of the information contained in the *Placita*.

(ii)

Secondly, and no less importantly, the current compromise, although the connection is expressed with varying degrees of explicitness, seems invariably to go hand in hand with the notion that weight for the Presocratics can only have been expressed by a fall, by movement downwards.

Here too it seems to me unlikely in the extreme that the necessary expression of weight in terms of movement downwards that we find in Aristotle should have applied, with anything like the same rigour, in the fifth century.

Again to take the extreme case: even if the atoms of Democritus had been explicitly stated to be without weight outside the formation of a cosmos, it seems to me that it would not necessarily follow that the reason for this would have been to keep the atoms from 'falling' in the void.

(iii)

Finally, this preliminary conclusion does not require us to

¹Aet. i 12.6, *cf.* i 3.18 (DK 68A47); ch.VIII §§ 1–2, pp.223–39 above; *cf.* ch.X § 4, pp.282–98 above.

abandon Simplicius to the simple confusion of Democritus and of Epicurus.

If the position is as I have stated it so far, then the texts of Simplicius which I have analysed will still stand as evidence that no explicit denial of weight found a place in Aristotle or in Theophrastus, even if, on this minimal interpretation of the evidence, we then suppose that Simplicius has in fact been led to his attribution of weight to atoms outside a cosmos, not by any positive evidence in Aristotle or in Theophrastus, but as a result of his own reflections.

From this, it need not follow that Simplicius' reflections have been determined to any significant extent by his knowledge of Epicurus. Simplicius is well enough able to distinguish earlier and later forms of Atomism on the question of movement and on the 'parts' of atoms. The texts of Aristotle will have provided sufficient encouragement for Simplicius to think that weight was an intrinsic, and therefore a permanent character of atomic substance.

Conclusion

Thus even in the context of this minimal and preliminary conclusion:

1. I do not suppose that Aetius preserves original information, explicitly denying weight to atoms that can be construed as being outside a cosmos.
2. I do not suppose that lack of weight was a necessary concomitant of the absence of a fall of atoms.
3. I do not suppose that Simplicius' evidence is the simple result of confusion with Epicurus.

I emphasise these points, not in order to try to stake out a personal claim to some measure of originality, but to try to stave off the crudification that I can well foresee of this preliminary, and minimal, conclusion to my argument.

1. The preliminary and minimal conclusion will be taken as the principal, if not the only conclusion to my argument.
2. The difference in content between this conclusion and the current compromise will be lost sight of, either by sup-

pressing the qualification that there cannot have been any express denial of weight to atoms that were outside a cosmos, or by attaching this qualification to what has been the current compromise.

3. Finally, this preliminary and minimal conclusion will be stripped of that structure of argument and evidence which alone can provide it with any hope of permanent significance as a contribution to the reconstruction and the interpretation of Presocratic philosophy.

§ 2—

The Probable Extension

The minimal and preliminary conclusion which I have outlined I regard as reasonably certain. This does not mean that I think it contains the whole truth, nor even that it contains all the truth that can be recovered from the evidence available. On the contrary, I have presented it as a minimal conclusion, precisely because it avoids the more problematical parts of the evidence. The minimal conclusion gains in certainty, because it loses in scope.

I have already stressed that the structure of evidence and argument which lies behind the preliminary and minimal conclusion is significantly different from that which is used to support what I have called the current compromise.

If we are to go beyond the minimal conclusion, then it is no less important to stress the difference of content between the two interpretations.

1. According to the current compromise, Aetius is right in his denial of weight to atoms, if they are atoms that are outside a cosmos.
2. The minimal and preliminary conclusion of this essay is that there can have been no explicit denial of weight to atoms that are outside a cosmos.

This distinction is obviously crucial to any attempt to extend the preliminary conclusion. Only if we conclude from a minimal interpretation of the evidence that there can have been no specific denial of weight to atoms that are outside a cosmos, are we then able to move on to consideration of whether a broader, if less

certain, interpretation of the evidence will allow us, with any reasonable degree of probability, to determine what expressions of weight may in fact have been attached to atoms that were outside a cosmos.

(i)

It is to this problem that I now turn.

It would be out of place to attempt any systematic characterisation of the thought of Democritus in a monograph which, however long, is intended to deal with the reconstruction of only one feature of Democritus' physical system.

On the other hand, it would be dishonest at this point to evade altogether the question: how likely is it, on general grounds, that Democritus will have simply failed to specify the presence, or the absence, of any expression of weight for atoms that are outside a cosmos?

In my study on Empedocles, I touched upon a similar question of principle: how likely is it that Empedocles will have failed to specify the temporal dimensions of his cycle? It is likely that Empedocles will have failed to specify the duration of the Sphere, in relation to the time of total Strife, or to the worlds of increasing Love and increasing Strife?¹

One of the distinctions which I drew there is needed also here. I think it is essential for students of early philosophy (among whom I include myself) to appreciate that certain distinctions, and notably that between what one may perhaps call material and abstract or spiritual forms of existence, were introduced only with the philosophies of Plato and of Aristotle, if indeed then. On the other hand, some at least of the later Presocratics were, I think, thoroughgoing in the exploitation of those categories and areas of thought which do form part of the fabric of their philosophy.

Our best and almost our only guide on this kind of point is Aristotle. For what is in question here is not the content of some particular belief, but some notion of how vigorous and far-reaching the philosophy of Democritus, or of Empedocles, may have been as a whole. This is a question which a merely doxo-graphical source, almost by its very nature, is precluded from

¹ *ECC* 71–5.

answering. It is also a point where the prejudices and preoccupations of the very few authors, most notably Aristotle, who will have read a large part or the whole of a philosopher's work, will be at their most virulent.

I limit myself to two points only, one general and one more particular.

(ii)

My more general point is simply that towards the beginning of his analysis of generation and *alloiosis* in the *De generatione et corruptione*, after some remarks on Plato, Aristotle turns to Democritus with a remark which against the background of his usual attitude towards earlier philosophers is remarkable for its generosity. He writes, i 2, 315a34-b1 (DK 68A35): *ἀπάντων φροντίσαι, ἥδη δὲ ἐν τῷ πᾶσι διαφέρει*.

'Generally speaking, no one has applied himself to any one of these problems, beyond the merest superficialities, with the exception of Democritus.

'Democritus seems to have applied his mind to the whole range of problems, as well as singling himself out from his contemporaries (ἥδη) by his method.'

I will not pursue this more general point except to add that in his evaluation of earlier theories of the nature of *sensibilia* Theophrastus joins Democritus and Plato in a way that is not dissimilar to the passage that I have quoted from Aristotle.

After remarking on the general paucity and the limitations of other earlier theories in the field, Theophrastus writes, *De sens.* 60 (DK 68A135): *Δημόκριτος δὲ καὶ Πλάτων ἐπὶ πλεῖστον εἰσὶν ἡμμένοι, καθ' ἕκαστον γὰρ ἀφορίζουσι*.

'Democritus and Plato are the only ones who have really come to grips with the subject. They advance a definition for each one of the sensibles.'

Was Democritus as thoroughgoing as this, and oblivious to

whether or not atoms outside a cosmos manifest weight?¹

(iii)

My more particular point employs an argument of a type which can be used only sparingly, and with great circumspection: it is an argument from silence.

The perils of this form of argument, applied to Democritus and on the same question of weight, are exemplified with chilling clarity by a remark of Mabillean. He is attempting to minimise the force of Aristotle's evidence on the atomic theory of weight, and writes:

'Les quatre ou cinq passages, ou Aristote expose au long la philosophie de Démocrite, ne contiennent rien sur la pesanteur ni sur la chaleur des atomes, ce qui a lieu de surprendre, quand il s'agit d'une théorie de cette importance.'²

The comparison with heat tells all. For we happen to know, from Theophrastus, that the explanation of heat in terms of spherical atoms was mentioned by Democritus 'often', *De sensi-bus* 68 (DK 68A135): ... καὶ ταῦτα πολλάκις λέγοντα, διότι τοῦ θερμοῦ τὸ σχῆμα σφαιροειδές.³

¹ It is true that Theophrastus concludes his account of Democritus, 'and so he fails to specify some points' (cap. 83 = DK 68A135). But this relates only to Democritus' theory of smell. The analyses that have been given of flavours (cap. 65–7 and of colours (cap. 73–8) among the *sensibilia* have in fact been very detailed.

Aristotle's generosity is perhaps less characteristic. Certainly his judgment in a famous passage of the *Metaphysics* is rather more severe: Socrates alone provides an answer to the Heraclitean flux with his search for 'general definitions' (M 4, 1078b12ff.); Democritus is here again singled out from 'the physical philosophers' (the Pythagoreans are in a different category), but only as having 'touched a little on the question', and as having given 'some sort of definition of hot and cold' (1078b19–20). Comparable passages: *Phys.* ii 2, 194a20–1 (where Democritus is joined with Empedocles), and *De part. anim.* i 1, 642a24–31. For the priority given to temperature in the passage from the *Metaphysics*, see p.377 n.1 below.

² *Histoire de la philosophie atomistique* 196.

³ For the reading θερμοῦ see above p.260 n. 1. Rather amusingly, Mabillean's remark is a direct transcription (unacknowledged) of a sentence in Lafaist,

(footnote continued on next page)

Surprise is a dangerous indulgence. There can in fact be no good reason for surprise that Aristotle does not elaborate upon the atomic theory of weight, outside the fourth book of the *De caelo*. If we imagine for a moment that we had to rely, say, solely on the evidence of Theophrastus, in order to know that there had been an atomic theory of weight at all, then it is only in the fourth book of the *De caelo* that we could reasonably have expected to find a deliberate analysis of the theory: and it would be only from its absence in that context that any argument from silence would have been worth its salt.

It is with due diffidence therefore that I adduce the following, very tentative consideration.

At least on questions of generation and *alloiosis*, Aristotle tells us, Democritus 'seems to have thought about everything'.

I have already listed the passages where Aristotle points out, with great emphasis, one of the questions which Democritus had not thought about: the cause and the nature (in Aristotelean terms) of the movement of atoms in the void.¹

In the third book of the *De caelo*, Aristotle argues at length, against Plato and against 'certain Pythagoreans', that the consequence of their theories is that there would be elements without weight.²

There is no criticism on this same score of Democritus, and, as we have seen, it is virtually on this point that Democritus is in fact opposed to Plato in book four of the *De caelo*.³

If the atoms had been left without any expression of weight outside a cosmos, would we not perhaps have had some criticism of the fact at this point, of the kind that we do happen to find (in what, historically, is an obviously erroneous form) in Alexander?⁴

(footnote continued from previous page)

Philosophie atomistique 70: 'Les quatre ou cinq passages où Aristote expose assez au long la philosophie de Démocrite ne nous présentent absolument rien sur la pesanteur et la chaleur des atomes'. The repetition is worse than it seems. Lafaist wrote as he did with only the evidence of the *De generatione et corruptione* in mind (cf. *Philosophie atomistique* 71). Mabillean, with the advantage of Zeller, has just quoted, 195, the relevant passages from the *De caelo* and from Theophrastus.

¹ Pp.237 and 261–2 above.

² *De caelo* iii 1, 299a25–300a19; cf. pp.84–5 and 214ff. above.

³ *De caelo* iv 2, 308b35–309a2 (in part DK 68A60); cf. ch.III, pp.80–114, esp. 83–6 above.

⁴ Alex., *Met.* 36.21–8 (in part DK 67A6); cf. ch.VII §§ 3–4, pp.211–22 above.

(iv)

There remains one other side to the thought of Democritus, which touches more closely on the evidence we have considered.

Studies of the Presocratics, and more especially studies of Anaxagoras and of Democritus, display often a strong leaning to what I can perhaps call pure intellectualism: the attempt to draw out the essentials of a system by a process of almost *a priori* deduction from what are thought of as certain central principles.

This is not altogether a reprehensible policy. At the end of the day, we cannot perhaps do better than attempt to reconstruct the essentials of ancient Atomism by placing the actual evidence on a conceptual web designed at once to hold the various pieces of evidence in place and to give some idea of the likely configuration of the parts that are missing.

But there is an extreme form of intellectualism in the reconstruction and the interpretation of ideas which I think completely perverts the historical reality, even in the case of a system as advanced (for its time) and as sophisticated (within the conceptual limits of its generation) as that of Democritus. The attitude I have in mind is perhaps most acute in studies which treat later and earlier forms of Atomism together. It is perhaps sufficiently exemplified by Robin, who in effect excludes the notion of weight from the earlier atomic theory, almost, it seems, for no other reason than that its introduction would interrupt the logical simplicity of that version of the earlier system which Robin has constructed for himself.

I hope that this is not too extreme a description of Robin's article, 'L'atomisme ancien', and of the relevant pages from the chapter on ancient Atomism in *La pensée grecque* (pp.136–9). As I have noted, Robin does recognise that the evidence for weight is 'une question particulièrement épineuse'.¹ But I think it is fair to say that at least part of the reason why Robin leaves the question open in his article, and why earlier, in *La pensée grecque*, he takes the attribution of weight to Democritus to be the result of confusion with Epicurus, is that his extremely abstract and intellectual analysis of the atomist theory leaves him with no room, conceptu-

¹ 'L'atomisme ancien' 211 (= *Pensée hellénique* 74–5); cited p.42 n.2 above; cf. p.154 n.1 above.

ally, for the atoms to have weight in the void. Thus in *La pensée grecque* the only 'déterminations positives' which Robin will allow to the atoms are those which he conceives of as 'impliquées par l'étendue' (pp.137–8). Weight is not one of these, and is therefore necessarily suspect.

'Toutes ces différences sont proprement géométriques et analytiquement liées à l'étendue. Il semble donc difficile, quoiqu'on en ait dit, d'y joindre la pesanteur, en relation avec la grandeur des atomes.' (*Pensée grecque* 138)

The same tendency is strikingly marked in Lafaist's treatment of weight in his *Dissertation sur la philosophie atomistique* (pp.11–13 and 58–79). Lafaist's treatise is a superb piece of clear and elegant French prose writing, but in it Lafaist makes virtually no concession to the possible presence of primitive or archaic traits in ancient Atomism. Lafaist does claim that the atoms of Leucippus are 'égaux en poids' (p.32), but the idea of differences in weight (pp.68–75) he dismisses precisely because it would upset the simplicity and the symmetry of the system that he has constructed for the ancient Atomists. Thus according to Lafaist Democritus retained only 'les propriétés essentielles de la matière' (p.21). For example, 'on ne conçoit pas la matière sans forme, par conséquent les atomes possèdent cette propriété' (p.22). But weight, for Lafaist, is not one of these. Therefore, although he rightly opens his discussion of weight in Democritus with an analysis of the passage from the *De generatione et corruptione*, he prefaces it with the remark that if what Aristotle says is true then Democritus 'aura fait faire un pas en arrière à l'atomisme' (p.69), and he follows his quotation of the passage by asking, 70:

'Reste à savoir si ces absurdités, avancées par Aristote, sont bien légitimement mises sur le compte de Démocrite.'

Placed in this context, the evidence of Aristotle has no hope of survival.¹

¹ The Cartesianism latent in Lafaist's analysis is explicit in later French interpretations: see pp.348–50 below.

(v)

To attempt to correct this general view of ancient Atomism would again be beyond the scope of this essay. I mention only one detail, which I hope to elaborate in a study parallel to this, on some early Greek theories of perception and intelligence.¹

In this study, I attempt to uncover two traditional types of explanation of intelligence and unintelligence: the one, a monistic explanation, identifying both intelligence and unintelligence with the supremacy of a single element; the other, essentially a pluralistic explanation, identifying intelligence with a balance of elements, and unintelligence with the predominance of a single element—a reversal, at this point, of the monistic explanation.

What is relevant to my present point is that Democritus occupies a reasonably well-established place within this second tradition.

Now on a certain view of Democritus' philosophy, this would be unexpected. Democritus' theory of the relativism of sensible perception is strikingly original: and we might well have thought that, apart from establishing the general principle of the dependence of *sensibilia* upon the interaction of atoms and sensible percipient, Democritus' energies would have been sufficiently occupied in the extreme elaboration of the mechanisms of sensation, and of the very various types of atom that constitute the source of *sensibilia*, all of which are attested to by the long chapters in Theophrastus' *De sensibus* (cap. 65–7, 73–8).

But in fact we discover, alongside this innovation and elaboration, that Democritus found room for—I am tempted to add 'was anxious to include'—a traditional conception of intelligence and of unintelligence in terms deriving from a balance, or a lack of balance, between traditional pairings of opposites.

Recognition of this kind of element in Democritus' thinking is essential if we are not to scorn the kind of considerations that I have attempted to draw from Aristotle's fragment on Democritus.²

Perhaps I have exaggerated the degree of animism latent in ἐμπίπτειν by translating 'to be at war' and 'to

¹ Cf. pp.254–5 above.

² Ap. Simpl., *De caelo* 294.33–295.24 (fr. 208 Rose = DK 68A37); ch.XI § 1, pp.303–10 above.

attack'. That was not my intention. But it is my intention to see in Aristotle's description of the atomic system at this point a much more traditional cast of concept and association than would be allowed in the rigorously intellectual interpretation of the atomic system of the kind that we find in Robin and in Lafaist.

(vi)

This traditional element is of course particularly susceptible to the withering winds of second-hand doxography.

Even the much richer and more exotic conceptualisations of Empedocles—the blissful Sphere, rejoicing in its immobility, the broad oath, Strife rushing forward to seize its honours when its turn is due—quickly wilt in the barren air of doxographical abbreviations. We have no more, often, than a simple opposition of unification and of separation.¹

The position of such traditional elements as there may have been in the atomic theory is still more fragile: for Democritus wrote provincial prose instead of inspired poetry, and Simplicius has not been able to record for us the *ipsissima verba*. Nor do I intend the comparison between Democritus and Empedocles to be altogether a fair one. It is intended at once as an extreme reminder of how much is lost, of traditional elements of thought and expression, in doxographical evidence, and therefore as an indication of the extreme value of Aristotle's fragment on Democritus.

For in this fragment we find Aristotle setting out, as never quite again elsewhere, to record Democritus' theory initially at least for its own sake, and therefore as one might say objectively. And both the value, and the incipient weakness, of that attempt is very likely symptomised in the conjunction that I have already dwelt upon of the two verbs for movement: *φέρεισθαι*.²

¹Empedocles, fr. 27.3–4, 28, 30. Contrast Justin Martyr (ob. circa 165 A.D.), *Cohortatio ad Graecos* cap. 4 (PG vi 249A, cf. *Dox.* 286–7 testimonia); [Galen,] *Historia philosopha* cap. 18 (xix 243–4 ed. Kühn = *Dox.* 610.18–20); Achilles Tatius (2nd–3rd century A.D.), *Isagoga in Aratum* cap. 3 (p.31.14–18 ed. Maass, cf. *Dox.* 287 testimonia); Hermias philosophus (3rd century A.D.?), *Irrisio gentium philosophorum* cap. 8 (*Dox.* 653.9–14); Epiphanius Constantiensis (ob. 403 A.D.), *Adversus lxxx haereses* iii 2: *De fide* ix 23 (iii 506.25–9 ed. Holl = *Dox.* 591.8–12). None of these texts is included in DK.

²See pp.307–10 above.

Democritus may, or perhaps more likely may not, have used the latter expression. But its appearance here, and its epexegetical relation to *στασιάζειν*, indicate clearly the potential reduction of original fifth-century terminology, and thought, to the standardised vocabulary of Aristotle and the doxographers.

(vii)

Aristotle's evidence in the fragment on Democritus is therefore of peculiar importance as the nearest approach that we can hope for now to Democritus' own expression of his theory.

Therefore the extension of Democritus' theory to include an expression of weight for atoms that find themselves outside a cosmos depends quite largely on how probable it is that any such expression of weight should find a place in the kind of context provided here by Aristotle.

To this question there is no simple answer.

Aristotle writes of size and of shape. He does not write of weight. There is a sense in which his silence is final. It precludes certainty.

On the other hand, against this silence, there are a number of convergent possibilities.

In a very similar context, Simplicius writes explicitly of weight. This could be simply the expression of his own ideas. On the other hand, Simplicius had almost certainly read the continuation of Aristotle's account of Democritus—he prefaces his transcription by saying that he is going to copy out only a short extract—and that is something that we cannot do.¹

From the fragment on Democritus, and from the *De anima* and from Theophrastus' *De sensibus*, we know that shape and size were associated with movement, and effected modifications of mobility and differences of speed.²

The mechanism of Aristotle's argument against void, in the *Physics*, is therefore in part Democritean: and there is a clear possibility that the remaining element in Aristotle's argument, the association of weight with differences in speed, may also therefore

¹*Phys.* 1318.30–1319.5 (in part DK 68A58); cf. ch. V § 3, pp.166–72 above. See also pp.299–302 above.

²Evidence and argument, ch. XI esp. §§ 1 and 3, pp.303–10 and 315–23 above.

be taken from the original theory, as are size and shape.¹

Differences of size and of weight, as factors affecting plurality and movement: there is the same conjunction of ideas in Plato's *Timaetus*.² A perilous source: a wealth of intricate detail, much of it heavily archaic in tone and character, with virtually no attribution. This conjunction of ideas in the *Timaetus* will perhaps be significant only for those who believe, as I do, that a very high proportion of the detailed imagery of the *Timaetus* is Presocratic in origin, a deliberate attempt by Plato to temper the rejection of physical philosophy put into (or recorded as coming out of) the mouth of Socrates in the *Phaedo*, and to resume the whole character of fifth-century physical speculations in subordination to the principles of his own epistemology and metaphysics.

(viii)

A rich, but a tricky terrain therefore. There is not the daylight of certainty. But there are more elements than can conveniently be ignored.

There can be no quasi-mathematical calculation of probability. The range of detail in Democritus' speculations about the precosmic movement of the atoms, the presence of traditional elements in his thinking, are not points that can be imposed by the simple statement of them.

My own calculation of probabilities is that very possibly an expression of weight was given to atoms in the void: the larger and heavier atoms perhaps distinguished by their force of impact, the smaller and lighter atoms distinguished by their greater mobility and speed of movement.

§ 3—

Summary

The Minimal Conclusion

The atoms have weight in proportion to, and dependent upon, their size. Larger atoms are heavier, and smaller atoms are lighter.

One body is lighter than another, if it contains a larger amount

¹*Phys.* iv 8, 215a25–9 and 216a11–21, *cf.* pp.187–9, 190–2 and 315ff. above.

²Evidence and argument, ch.XI § 2, pp.311–15, esp. pp.313–14 above.

of void. The volumes of the bodies being compared are either not stated, or held to be equal.

Within the cosmos, the weight of atoms is expressed by the distribution of larger and smaller, or heavier and lighter, atoms in a *dine*, and as an element in the definition of lightness in terms of void.

There is no explicit denial of weight to atoms that are outside a cosmos, and there is no necessary assumption that weight must be expressed as movement downwards, nor therefore that atoms which are outside a cosmos, where they move about in all directions, must be weightless.

The Probable Extension

The weight of atoms moving in the void was expressed by force of impact and by speed. The larger and heavier atoms perhaps have a stronger impact. Smaller and lighter atoms are the more mobile, and move the more quickly.

Chapter Thirteen— Perspective

§ 1—

Modern Scholarship: The Progress of Error

Having reached this conclusion, I turn at once to a subject that has lain uneasily at my side throughout the preceding chapters.

After considerable heart searching, I decided to limit my discussion in most of the text hitherto, and in the majority of footnotes, to work that has appeared in the last seventy years or so, since the fifth edition of Zeller (1891) and the second edition of Burnet (1908). In his fifth edition Zeller had had the opportunity of considering the arguments of Brieger (1884) and of Liepmann (1885) against the theory of downward movement for Democritus' atoms, and had decided against them.¹ In the second edition of his *Early Greek philosophy* Burnet put forward the combination of views that has since been most fashionable: that the atoms do not move downwards in the void, and that they have weight only subsequently to the formation of a cosmic vortex.² It is, I think, a fair reflection of contemporary opinion that in the second volume of his *History of Greek philosophy* Professor Guthrie adopts essentially Burnet's view, with Zeller's interpretation offered as the discredited alternative, and with brief acknowledgment to Brieger and to Liepmann in a footnote.³

However, in reflecting contemporary opinion as he does, Professor Guthrie symptomises that neglect of nineteenth-century scholarship which in this instance, as often, has led to a lack of flexibility in response to the sources of our knowledge of pre-Platonic philosophy, and to the unreflective acceptance of a

¹*Philosophie der Griechen* 5th edn 868–88 = ZN 1076–99. The works by Brieger and Liepmann, *Urbewegung* and *Mechanik*, have already been cited: full references may be recovered from the Bibliography.

²*Early Greek philosophy* 2nd edn (1908) 394–9 (= 3rd edn 341–6).

³*History* 400–4, see especially 401 n.1. Two recent contributions, by Hahm and by Furley, reached me too late to be included in this survey: details are given in the Bibliography. It is however significant that Hahm reproduces essentially Burnet's view, while Furley adopts a version of Zeller's interpretation.

familiar distribution of evidence for particular problems. It would be satisfying indeed to think that certain permanent gains had been won by the scholarly labours of our predecessors, and that from the firm basis of certain achieved positions one could advance to more remote or to more detailed areas of reconstruction, or to more recondite forms of interpretation and analysis: but only in a few cases is this so. More often, neglect and ignorance of the variety of interpretations offered by earlier scholarship, the trust that Zeller or even Burnet will have skimmed the cream from earlier work, leads either to the unconscious repetition of earlier constructions which had already in their day been subjected to at least partial refutation, as is instanced by modern non-cyclic interpretations of Empedocles' cosmic system, or at least, as in the present case, to the narrowing of one's choice to alternatives that seem attractive only because they rest on a simplification of the doxographical evidence, and on criteria of interpretation that require no fresh effort of the historical imagination in the transposition of our own categories of thinking towards the very different habits of thought that characterised philosophical reflection in the century before Plato.

In the main body of this monograph I have therefore restricted my citations and discussion of nineteenth-century interpretations of weight to the occasional footnote, not because I think that more recent scholarship is necessarily better, but because it is more influential. The first section of this final chapter of my study of Democritus is intended, briefly, to right the balance, and to acknowledge that several elements essential to my present interpretation had been mooted by scholars in the nineteenth century, while at the same time I shall try to explain why in nineteenth-century discussions of the problem these elements were never brought together into a single synthesis, nor related to an analysis of the evidence as a whole.

(i)

Interpretations from the earlier part of the nineteenth century are listed and analysed briefly by Liepmann.¹ His list does not,

¹*Mechanik* 10–15.

however, include a potentially fruitful definition of weight that appeared in an account of Democritus by Renouvier.

'Le poids ne subsiste pas dans l'atome, mais il se manifeste dans le choc, et on ne doit pas entendre par ce mot, *poids*, une force unique d'une direction constante, mais cette force générale, variable de grandeur et de direction, qu'exerce tout atome que se meut, sans, pour cela, la porter en soi comme une qualité native et essentielle hors du mouvement et des composés.'¹

Unfortunately only one element in this definition, and as it happened the wrong element, came to be taken up by those of his fellow countrymen who took note of Renouvier's work. Instead of reflecting on the possible expression of weight as force of impact, they seized instead upon the notion of weight as a factor which, like position or arrangement, would come into play only when one body was related to another. This deflection of Renouvier's original conception arose through a comparison with Descartes proposed by Pillon. Descartes himself had sought to distinguish his own theory from that of Democritus, on a number of points, including the question of weight: Democritus, he held, had attributed weight to the atoms; he himself sought to deny that there was weight in any body, 'en tant qu'il est considéré seul, pource que c'est une qualité qui dépend du *mutuel rapport* que plusieurs corps ont les uns aux autres' (Descartes' own italics).² Pillon denied that Democritus' atoms had weight, and therefore found it easy to identify Descartes' view with the version of Democritus' theory that had been given by Renouvier.³ This conflation of the two ideas, that of Descartes and that of Renouvier, was repeated by Mabileau, who concluded of Democritus and of Descartes together that:

'Aucun corps n'est considéré comme pesant, en tant qu'il est pris isolément.'⁴

¹Manuel i 246.

²*Principia philosophiae* iv 202. An account of Descartes' theory, and of its fortunes among his immediate successors, may be found in Paul Mouy, *Le développement de la physique cartésienne 1646–1712* (Paris, 1934).

³F. Pillon, 'L'évolution historique de l'atomisme' 121–3.

⁴*Histoire de la philosophie atomistique* 199.

Once expressed in this form, Renouvier's interpretation was fatally vulnerable, for now it conflicted directly with the stipulation in Theophrastus' account of the atomic theory of weight: 'if each atom were taken separately on its own . . .'. The inevitable death blow was dealt by Goedeckemeyer.¹

(ii)

The potentially fruitful feature of Renouvier's definition had lain in its attempt to give weight a positive meaning other than that of cause of movement in a specific direction. The authors listed by Liepmann were for the most part concerned, in however tentative and confused a fashion, to assert or to deny that weight was cause of the atoms' movement. This preoccupation was given clearest and most forceful expression by Zeller, who attributed to Democritus the idea which is attacked by Lucretius, and in a slightly different form by Alexander, to the effect that the atoms move downwards in the void, with greater or less speed according to their weight, and thus become entangled with one another without any need for a *declinatio*.²

Zeller's pursuance of his thesis exerted upon the interpretation of the evidence, and in particular upon the interpretation of the doxographical evidence and of Simplicius, what can I think best

¹Goedeckemeyer, *Epikurs Verhältnis* 12–13. Even before Goedeckemeyer's fatal attack, the alternative element in Renouvier's definition had degenerated into the idea that the atoms are moved by 'impulsion' or 'choc', as an *alternative* to their having weight, precisely as in the entry in Aetius (p. 223 above). This at least is how the case appears in Félix Ravaisson, *Essai sur la métaphysique d'Aristote* ii (Paris, 1846) 89–90, and in Liard, *De Democrito philosopho* 43–4. In Renouvier himself the idea is that 'force' or 'choc' is an *expression* of weight; this is a much more subtle idea, however implausible may have been the interpretation that Renouvier then tried to give of the formula in Aristotle. (Renouvier's interpretation of ὑπεροχή has been quoted above p.45.)

The uncertainty, whether 'force' is an admission or a denial of weight, is neatly illustrated by the way in which an English writer repeats (without acknowledgment) Renouvier's formulation, George H. Lewes, *The history of philosophy from Thales to Comte* 5th edn i (London, 1880) 102:

'Democritus also denied that atoms had any weight; they had only force, and it was the impulsion given by superior force which constituted weight.'

²Zeller, ZN 1066–8 and 1076–99. Lucretius, ii 225–9; Alexander, *ap. Simpl. Phys.* 679.12–22; *cf. Epicurus, Ep. ad Her.* 61; see pp.185ff. above.

be described as a gravitational pull from which even those who have abandoned Zeller's conclusions have still scarcely been able to extricate themselves. For Zeller claimed as primary evidence for his thesis precisely those passages where Aristotle and Theophrastus attribute weight to the atoms, and more particularly the passage where Simplicius attributes the movement of the atoms to weight.¹ The erosion of the testimony of Aristotle and Theophrastus has been a slow and only a partial process, taken to its most extreme by Cherniss.² Simplicius has been an easier victim. Even where they have been able to disprove Zeller's conclusions on the downward movement of the atoms, Zeller's opponents have been unwilling to rescue Simplicius' evidence as a whole from the limbo of self-contradiction, or of plain error, where alone he seems no longer able to threaten their arguments.³

Of the two refutations of Zeller by Liepmann and Brieger, that by Brieger is at once the clearer and I think on the whole the more competent: it is also the more obviously at a loss on the question of weight. Thus at the beginning of his essay, Brieger rejects the attribution of movement 'by weight' to the atoms, as testified by Simplicius; while at the end of this first part of his essay he equally rejects Aetius' denial of weight to the atoms.⁴ Simplicius' evidence Brieger rejects because he sees it as telling in favour of downward movement. Aetius' evidence he sees as possible only because the atoms did not move downwards, and were therefore supposed to be weightless; but he treats the denial of weight as nonetheless

¹ These passages have been studied: Aristotle, *De gen. et corr.* i 8, 326a9–11 (in part DK 68A60), ch.II, pp.41–79 above; *De caelo* iv 2, 308b35–309a2 (in part DK 68A60), ch.III, pp.80–114 above; Theophrastus, *De sens.* 61–2 (DK 68A135), ch.IV § 1, pp.115–31 above; Simplicius, *Phys.* 1318.30–1319.5 (in part DK 68A58), ch.V § 3, pp.166–73 above.

² Thus Cherniss claims that of the two passages where Aristotle is supposed to attribute weight to the atoms, the one (*De caelo* iv 2, 308b28–309a11) does not describe atoms at all, while in the other (*De gen. et corr.* i 8, 325b36–326a14) Aristotle does not attribute 'real' weight to the atoms. See *ACP* 97–9 and 209–13; for the equivocation between absolute weight and 'real' weight, esp. *ACP* 211 n.253; for the denial of absolute weight to the atoms, esp. *ACP* 211 n.253. Contrast pp.6ff. above (the denial of absolute weight); pp.46ff. above (the passage from the *De gen. et corr.*); pp.81ff. above (the passage from the *De caelo*).

³ For attacks on Simplicius' consistency, and integrity, see above pp.269ff.

⁴ *Urbewegung* 7–8 and 12–13, cf. 'Urbewegung' 587 and 596. *Simpl. Phys.* 1318.30–1319.5 (in part DK 68A58), ch. V § 3, pp.166–73 above. *Act.* i 12.6, cf. i 3.18 (DK 68A47), ch. VIII §§ 1–2, pp.223–39 above.

mistaken, because of the evidence of Aristotle and Theophrastus. Thus Brieger ends up asserting that the atoms have weight, but not allowing their weight to have any effect on their movement or on any other aspect of their behaviour. His thesis is therefore totally exposed to Burnet's objection:

'This weight, since it produces no effect, does not yet exist.'¹

Liepmann attempts to be a degree more positive, in speaking of a latent weight or *Pseudoschwere*, which he sees as consisting primarily in resistance to force.² But in attempting to explicate this notion he is driven to write such desperate, although at the same time such promising, sentences as that:

'Die Democritische Schwere . . . in einem Sinne Schwere, und im anderen Sinne doch nicht Schwere war.'³

Brieger's failure to attribute some positive expression to weight is the more remarkable in that he concludes the first part of his original essay with some remarks, admittedly in a very tentative form, on the possibility of the atoms' moving with differences of speed or with differences in their force of impact.

'Wenn wir nun fragen, wie wir uns die Urbewegung der Atome des näheren denken sollen, so sind wir fast allein auf Schlüsse gewiesen, und zwar auf Schlüsse aus einem äusserst dürftigen Material. . . . Ob das grössere Atom mit grösserer Kraft stossen, das mit grösserer Kraft gestossene sich schneller bewegen soll . . . diese und andere nahe liegende Fragen vermag ich nicht zu beantworten.'⁴

The idea of differences of speed, as we have seen, occurs in book four of Aristotle's *Physics*, where it is offered precisely as an expression of differences in weight.⁵ Brieger makes no mention of

¹ *EGP* 345 n.1.

² *Mechanik* 28–30, cf. 42, 47.

³ *Mechanik* 32–3.

⁴ *Urbewegung* 13.

⁵ *Phys.* iv 8, 215a25–9 and 216a11–21, cf. pp.187–9, 190–2 and 315ff. above.

weight, and expresses the idea solely in terms of the size of the atoms. Since, however, the weight of atoms is determined by their size, the distinction is only a formal one, and Brieger's tentative question therefore comes close to expressing the theory which Aristotle criticises in the *Physics*.

The extreme tentativeness of Brieger's proposal, and his avoidance of weight at this point, are both, I think, symptomatic of his unresolved attitude towards evidence that had been employed by Zeller. For Zeller had attached this passage in the *Physics* to texts in Epicurus and Lucretius, and had employed the whole as primary evidence for his interpretation of the atoms moving downwards, with different speeds, in the void.¹

In attempting to neutralise Zeller's employment of the passage in the *Physics*, Brieger had argued that it was not directed specifically to Democritus, or indeed against any particular thinker.

'Das Ergebnis, zu welchem er gelangt, dass sich nämlich im Leeren nicht eines rascher als das andere bewegen könne, aber auch nicht alles gleich schnell, woraus folge, dass, wenn es eine Bewegung gäbe, kein Leeres existiere, *interessiert uns hier nicht*' (my italics).²

I have italicised the final phrase because it is so clearly at odds with Brieger's employment of virtually this idea, minus weight, in his final, tentative reflections on the nature of the atoms' movement only a page or two later.

But this is not the whole extent of Zeller's influence on Brieger's interpretation of this passage. Brieger continues:

'Nur das wollte ich beweisen und glaube es bewiesen zu haben, dass kein Grund vorliegt, die widerlegte Annahme eines ungleich schnellen *Falles im Leeren* eher dem Demokrit als irgend einem andern von den Naturphilosophen zuzuweisen, ja dass überhaupt an kein bestimmtes System zu denken ist' (my italics).³

¹ Especially ZN 1088–9.

² *Urbewegung* 9–10.

³ *Urbewegung* 10.

But in Aristotle the movement that is envisaged in the void, and that is made the object of criticism, contains no necessary connotation of being movement exclusively downwards. It seems so to Brieger, only because Zeller had joined this passage to those in Epicurus and Lucretius, as part of his thesis of Democritus' fall of atoms. Brieger has failed to break away from Zeller's interpretation and conflation of the evidence, and so has failed to appreciate that, on his own interpretation, the passage could as well refer to Democritus as not.¹

(iii)

The question of differences of speed is the more interesting in that it was singled out in a remarkably straightforward and perceptive passage in a review of Brieger by Lortzing.² In the course of a sympathetic, and indeed flattering, review, Lortzing wrote:

'In der hauptsache müssen wir dem verfasser beipflichten, darin nämlich, dass aller wahrscheinlichkeit nach die älteren atomiker nicht die fallbewegung der atome als die primäre angesehen haben. Eine andere frage ist die, ob sie damit zugleich auch jede wirkung der schwere auf die atomenbewegung geleugnet haben. Es wäre doch wunderbar, wenn sie den urkörpern eine aus ihrem wesen resultierende eigenschaft beigelegt hätten, die völlig unwirksam und latent bliebe. Ohne zweifel ist nach Demokrit die ursache aller bewegung der stoss; aber die stärke dieses stosses und damit auch die schnelligkeit der bewegung hängt von der ungleichen masse oder schwere der atome ab.'³

Even in Lortzing, however, the influence of Zeller, in his employment of Lucretius, can be felt, for Lortzing continues:

¹ The only connotation of movement downwards—or upwards—lies in the association of weight and size: Aristotle assumes that the larger body will travel the more quickly, as in his own theory of the movement of earth and fire. This in turn means that the correlation of size and weight in Aristotle's argument will have to be modified, if the mechanism of Aristotle's argument is to apply directly to Democritus: see pp.323–9 above.

² *Philologischer Anzeiger* 15 (1885) 578–83.

³ *Philologischer Anzeiger* 15 (1885) 581: the German is printed thus in the original.

'Denn eine ungleichheit der bewegung muss doch wohl Demokrit angenommen haben, da ohne diese ein aufeinandertreffen der atome kaum denkbar wäre.'

A difference of speed will indeed be needed if the atoms are moving downwards, which is as the theory appears in Lucretius, in Alexander and in Zeller: but there will be no necessity for the atoms to have differences of speed, in order to catch each other up, if, as on Brieger's theory, they are moving in different directions.¹

This blemish in Lortzing's presentation of his suggestion may possibly in part explain why the whole idea is ignored when Brieger returns to the fray some twenty years later.² But there is, I think, a more powerful influence at work to confuse Brieger's powers of receptivity, even in his later essay. In the final edition of his great work, Zeller had rejected Brieger's and Liepmann's interpretation, forcefully and at length.³ Even in his later essay, therefore, Brieger's whole preoccupation is still centred on countering Zeller on the narrow front of downward movement, while leaving in abeyance any radical re-thinking on the question of weight. Thus it is fascinating to observe that in his rehandling of the passage from book four of the *Physics*, Brieger successfully detaches the passage from its identification with Epicurus and Lucretius, and rightly argues that taken in itself the passage affords no evidence for downward movement. But Brieger studiously avoids any repetition of his earlier suggestion, despite its endorsement by Lortzing, that differences of speed might have belonged to the atoms, an idea which in the absence now of any connection with downward movement should only have become the more plausible. Instead, he argues that the passage in the *Physics* is couched exclusively in terms of Aristotelean categories, and he concludes, almost, one feels, as a rebuke to his earlier tentative intuitions:

'Welcher Art aber nach atomistischer Ansicht die Urbewe-

¹ Lucretius, ii 225–9; Alexander, *ap. Simplicius Phys.* 679.13–19; *cf.* pp. 185–90 above.

² Adolf Brieger, 'Die Urbewegung der Demokritischen Atome', *Philologus* 63 n.F. 17 (1904) 584–96.

³ *Philosophie der Griechen* 5th edn (1891) 868–88 (= ZN 1076–99).

gung im Leeren sein soll, daraus ist aus dieser Stelle durchaus nichts zu entnehmen.¹

The reason, I think, why Brieger curbs in this way his earlier intuitions is that he has felt it necessary, for the safety of his thesis, to endorse Zeller's definition of weight. In his final edition, Zeller had written:

'Unter der Schwere hat . . . niemand im Altertum etwas anderes verstanden als diejenige Eigenschaft der Körper, vermögen deren sie sich nach unten bewegen, wenn ihnen dies nicht durch ein äusseres Hindernis verwehrt wird.'²

Brieger repeats precisely Zeller's formula:

'Unter Schwere verstehe ich . . . die Eigenschaft, dass die Atome sich in einer bestimmten Richtung, wir sagen: nach unten, bewegen, wenn sie nicht unterstützt werden.'³

Clearly, once we adopt this definition of weight, Democritus' atoms could not move with differences of speed according to their size or weight without their also being at once committed to movement downwards.

(iv)

But the truth is that it is impossible, as often as not, to hive off one element only in the reconstruction or the interpretation of a piece of early philosophy, and hope to achieve a definitive solution to this point, without a conscious grasp of the neighbouring conceptions which might impinge upon it. Brieger hopes to demolish Zeller's argument on movement, while accepting *carte blanche* Zeller's conception of weight. But Zeller's conception of weight is in fact doubly wrong. There is no single ancient conception of weight. Weight, for the Presocratics, is not primarily or exclusively expressed by movement in a specific direction. But so

¹ 'Urbewegung' 593.

² *Philosophie der Griechen* 5th edn 876 (= ZN 1084).

³ 'Urbewegung' 586.

authoritative is Zeller's tone that although Zeller offers no evidence to support his sweeping definition nonetheless Brieger accepts his definition unflinchingly, although in doing so he not only abandons his earlier intuitions about differences of speed: in accepting blindly Zeller's definition of weight, Brieger lays his whole interpretation open to one or other of two fatal objections.

1. If the atoms have weight, they must move downwards.
2. If the atoms do not move downwards, then they have no weight.

The second alternative had already been adopted by Dyroff:

'... Demokritos den ursprünglichen Atomen Schwere und Leichtigkeit nicht beigelegt hatte, sondern ... er beide Eigenschaften erst bei den Atomen der Erde und bei den Sinnesqualitäten eine Betrachtung unterwirft.'¹

Brieger was able to write slightly, in his later essay, of the idea that the earth should be light as well as heavy.² But his objection touches only the surface of Dyroff's idea. By accepting Zeller's definition of weight, and by leaving the precosmic atoms therefore without any expression of weight possible to them that would not lead at once to Zeller's theory of a fall of atoms, Brieger inevitably left the way open for Burnet to re-state Dyroff's interpretation, which he did by adding several pages to the second edition of his *Early Greek philosophy*, substituting only world for earth.³ Even this change is less important than it may seem from Burnet's brief acknowledgment of Dyroff.⁴ For in writing of the earth being light as well as heavy, and in limiting the introduction of light and heavy to the earth, instead of to the cosmos at large, Dyroff was doing no more than try to follow faithfully the doxographical accounts of how the world grows from the separation of light and heavy elements from within what is called the earth.⁵ Burnet's supposed correction is a simplifica-

¹ *Demokritstudien* 35.

² 'Urbewegung' 586.

³ *EGP* 2nd edn (1908) 394–8 (× 3rd edn 341–6).

⁴ *EGP* 2nd edn 398 n.1 (= 3rd edn 344 n.4).

⁵ Especially Aet. iii 13.4 (DK 68A95); cf. p. 153 n.3 above.

tion of Dyroff's thesis; it is in no way an improvement upon it; while Brieger's slighting reference to the existence of both heavy and light elements within the earth simply ignores the refinement of Dyroff's argument.

Much more to the point was Brieger's argument against Dyroff that the atoms have all the same nature, and cannot therefore differ radically in having, or in not having, weight, although there is a touch of wilful polemic in Brieger's objecting that it is impossible for some atoms to have weight and for others not to, while Dyroff's idea is clearly that the same atoms, at different times, have, and do not have, weight. Brieger writes:

'Darauf ist zu erwidern, dass die Atome absolut wesensgleich sind, Aristot. de caelo. I 7. 275b29ff., also können nicht die Erdatome Schwere haben, während die übrigen, d.h. die nicht in die Erdverbindung eingegangenen Atome gewichtlos sind.'¹

It is a more serious fault that Brieger refers only to the *De caelo*. In doing so, he shows that he is still too absorbed in controversy to be able to exploit the evidence independently of the use that Zeller had made of it. For in the passage referred to from the *De caelo* Aristotle writes only that the atoms have all the same substance, and therefore must be all *either* heavy absolutely *or* light absolutely. From this it could perhaps conceivably be argued (in Dyroff's favour) that in fact therefore they can have been said to be neither. Far more to the point, for Brieger's argument, is Simplicius' statement that according to Democritus the atoms 'have weight in virtue of the uniformity of their nature'. But in handling this passage, Brieger is still concerned only to argue against Zeller that the downward movement of bodies there spoken of is the movement of compound bodies and not of atoms, and is movement within the cosmos and not outside the cosmos.² Thus Brieger's potentially most valuable ally, Simplicius, is lost. His point against Dyroff is left to stand, faulted at once by his own polemic, and unattached to the one piece of ancient evidence that supports

¹ 'Urbewegung' 586. For the passage from the *De caelo* see esp. pp.11–15 above.

² 'Urbewegung' 589–90. Simpl., *De caelo* 569.5–9, cf. pp.154–7 above.

it most clearly: Simplicius' statement that the atoms have weight, as it were in their own right.¹

(v)

Burnet ignores Brieger's objection. He takes instead, in support for his revision of Dyroff's theory, Brieger's final argument: the

¹I have traced the route—Zeller, Liepmann, Brieger, Dyroff—which, to judge from the references given in *EGP*, in fact led Burnet to his interpretation.

An alternative route lay open. A number of writers argue from Democritus' general theory of the nature of perception that the atoms are without any qualities, such as heat or flavour, and that they are therefore without weight. This is the argument in Lafaist, *Philosophie atomistique* 73–5, and in Johann E. Erdmann, *Grundriss der Geschichte der Philosophie* 4th edn i (Berlin, 1896) 545, and with some qualification in Renouvier, *Manuel* i 245. It also appears fleetingly in the passage I last quoted from Dyroff, *Demokritstudien* 35.

Despite some sensible and cogent remarks against this view by Liepmann, *Mechanik* 32, the idea reappears in Hamelin, and there takes on a form very close to Burnet's interpretation, 'La pesanteur de l'atome' 198:

'Il demeure acquis en effet . . . que Démocrite (ce qui est d'ailleurs bien connu) nie l'existence des qualités affectives dans les atomes mais les fait dépendre toutefois des propriétés géométriques des atomes: tel est expressément le cas de la chaleur et tel paraît être le cas de la pesanteur.'

Hamelin continues, 198 n.3:

'Si ce n'est peut-être que, à considérer les atomes qui font partie d'un monde, la pesanteur y existe en elle-même telle qu'elle nous apparaît, parce qu'elle est une force dont l'atome se trouve alors réellement doué, d'où qu'il l'ait reçue.'

More recently, this interpretation seems to have lapsed, though the idea that the atoms are without weight because they have no sensible qualities does crop up in passing in I.A. Boricevskij, 'Demokrit und Epikur im Kampf um die Grundlagen des Atomismus' [in Russian], *Archive for the history of science and technology* [in Russian], series 1, number 8 (1936) 125. See also Hahm in the Bibliography.

The relation of 'subjective' (hot, red, sweet) to 'objective' properties (round, small) is of course a crucial question in the analysis of ancient Atomism. I have touched upon the point earlier, pp.256–8; and in the final chapter of my second essay I shall argue that the inclusion of weight among the 'subjective' properties was a step taken only by Plato. But I shall not attempt to deal with the atomic theory of perception as a whole: although it is always dangerous to deal with the ideas of any thinker piecemeal, I think that in this case the evidence for weight must be analysed on its own terms, before the notion of weight can properly be related to the larger question of the Atomists' conception of material bodies and their relation to human perception or intelligence.

use of ἰσορροπῶν in Diogenes Laertius.¹ Brieger had argued from this that the precosmic atoms 'im Gleichgewichte schwebten'.² Burnet changes 'im Gleichgewichte' to 'the absence of weight', although in adapting Brieger's argument he fails to appreciate that, as his own translation of the passage from Diogenes, copied out from the first edition a few pages earlier, had made reasonably clear, this description applies not to atoms outside the cosmos, but to atoms that are already caught into the beginnings of a cosmogonical process.³

But if only because Burnet and Brieger are at this point companions in error, it is easier to ask: what difference of substance is there in Burnet's and Brieger's interpretation of ἰσορροπος?

Burnet's vacillations on the subject are chillingly clear, if we compare the wording of the second and the third edition.

'... the word ἰσορροπία is therefore that in which the tendency in one direction is exactly equal to the tendency in any other, and such a state is more naturally described as the absence of weight than as the presence of opposite weights neutralising one another. *That way of looking at it may be useful from the point of view of later science, but it is not safe to attribute it to the thinkers of the fifth century B.C.*'⁴

'... the word ἰσορροπία is therefore that in which the tendency in one direction is exactly equal to the tendency in any other, and such a state is more naturally described as the absence of weight than as the presence of opposite weights neutralising one another.'⁵

¹ ix 30–1 (DK 67A1); see esp. ch. VII § 2, pp.207–10 above.

² 'Urbewegung' 596.

³ *EGP* 338–9, cf. 345.

⁴ *EGP* 2nd edn 398.

⁵ *EGP* 3rd edn 344–5. I have marked in italics the differences between the two editions.

In the second edition it follows naturally enough perhaps to argue that $\rho\omicron\pi\eta$ is cause and not the effect of weight, which is how the idea appears in the third edition.

The new premiss is in any case a sophism. If $\rho\omicron\pi\eta$ is used in the context of weight, then the movement, or the tendency to movement, indicated by the word is quite simply the expression of weight: it hardly makes sense to choose between saying that the movement is the cause or is the effect of weight, outside the context of a particular theory of weight; and if we were forced to choose, then it would even seem more natural to say perhaps that the movement is the effect of weight.¹

But the real confusion of Burnet's argument lies in his attempt at once to disengage $\iota\sigma\acute{o}\rho\rho\omicron\pi\omicron\varsigma$ from any connotation of weight, and at the same time to conclude that the meaning of the word in Democritus is 'the absence of weight'.

1. If $\iota\sigma\acute{o}\rho\rho\omicron\pi\omicron\varsigma$ need not, and in this passage does not, have any necessary connotation of weight then we can conclude *neither* that it means of equal weight *nor* that it means without weight.

2. If, on the other hand, we are to make the choice between 'im Gleichgewichte' and 'the absence of weight', then it can be only because $\iota\sigma\acute{o}\rho\rho\omicron\pi\omicron\varsigma$ in this context *does* refer to weight: whether it then refers to the cause or to the effect of weight, makes little difference.

¹ The distinction makes some sense in the context of Descartes' theory (cf. pp.349–50 above), where movement is primary and weight is in some sense secondary, so that Pilon can claim, for Democritus as for Descartes, that weight 'est un résultat, non un principe du mouvement' ('L'évolution historique de l'atomisme', 122). Mabillean misquotes Pilon's view as that 'la pesanteur est ici le résultat et non la cause du mouvement' (*Histoire de la philosophie atomistique* 199). It is tempting to see Burnet's formula (1920) that $\rho\omicron\pi\eta$ 'is the cause rather than the effect of weight' as simply a reversal of Mabillean's misquotation (1895) of Pilon (1891). If so, the origin of the formula would demonstrate its weakness. The assertion or the denial of Pilon's formula hardly has meaning outside the context of Cartesianism—or unless we distinguish between weight and momentum.

And in truth, if having threaded our way through Burnet's confusion, we pause to consider, either more particularly, whether ἰσόρροπος is the more likely to mean 'of equal weight' or 'of no weight', or more generally whether it is better to say that the atoms outside a cosmos have a weight which they do not express until they are drawn into a cosmos, or to say that at first they have no weight and that later they gain weight, then we soon realise, I think, that in either case we are faced with a distinction with very little difference. For if this were the state of affairs which the evidence for ancient Atomism presented us with then the most obvious conceptual expression to the solution would be to say that the precosmic, or inter-cosmic, atoms have potential weight: and when it is then pointed out that the distinction of potential and actual has no firm footing in pre-Platonic thought, it will be obvious that the distinction between 'no weight' and 'no weight that is as yet apparent' is fairly arbitrary, and that the attraction of choosing the simpler formulation lies, if not in its *naïveté*, then in the desire to accommodate the entry in Aetius which declares that Democritus' atoms 'have no weight', on the crudely simplistic principle that one should find a place in one's reconstruction for as much of the ancient evidence as possible, no matter what its relative worth.

But the final fallacy in Burnet's hypothesis does not lie in his false choice between the atoms' having no apparent weight and their having no weight at all. It lies in the suppression from his third edition of the sentence which concluded his original analysis of weight:

'That way of looking at it', namely as the presence of opposite weights neutralising each other, 'may be useful from the point of view of later science, but it is not safe to attribute it to the thinkers of the fifth century B.C.'

This final sentence comes dangerously close to admitting that ἰσόρροπος as 'the absence of weight' instead of 'the presence of opposite weights'. No such sleight of hand can make it 'safe' to transpose to the fifth century the terminology of the fourth century or later.

The truth is that ἰσόρροπος symptomises the whole notion of weight conceived primarily and necessarily in terms of movement that is peculiar to Plato and to Aristotle. It is this notion that Burnet, Brieger and Zeller alike, unreflectingly transfer to the fifth century when they suppose either that because the atoms have weight, they must move downwards, or that, since the atoms do not move downwards, then they can have no weight, or at least no appearance or manifestation of weight.¹

(vi)

It is this same notion of weight that determines the account of Atomism in the current manuals, and that in so doing shows how little has yet been learnt of what the Presocratics have preeminently to teach us: the difficulty, the fascination, and the relief, of escaping from unconscious presuppositions, and from ingrained habits of thought.

An otherwise sensible scholar (with the limitations as well as the advantages implied in that description) writes recently, when he comes to the question that has been the subject of this essay:

'We may here pause to consider what weight means: it means a tendency to move consistently in a certain direction, what we call "downwards", and a resistance to "upward" movement.'²

¹ The conceptual error that I have sought to uncover should not blind us to the doxographical use that can properly be made of the two terms ἰσορρόπων ... μηκέτι δυνάμενων περιφέρεισθαι can apply, or so I have argued, only to the movement on atoms *at an early stage* in the formation of a cosmos (*cf.* pp.203–11 above).

From a *doxographical* point of view therefore, the error in Brieger and in Burnet consists in attempting to apply the *positive* use of the term ἰσόρροπος, implied by Diogenes, to a time *prior* to the formation of the cosmos, as described in the *Timaeus*. The accompanying *conceptual* error consists in the supposition (1) that atoms which are outside a cosmos, and which do not fall, cannot have weight, and (2) that 'balance' can properly be accounted a lack of weight.

² Kirk, *Presocratic philosophers* 415.

If only the writer of these words *had* paused to think. And if only, in pausing, he had taken time to reflect not on what weight 'means', as though meanings existed in themselves, nor even on what weight 'means' for us, but on what weight might have meant for those first philosophers of Greece, whose ways of thinking are related to, but are remote from, our own.

§ 2—

Early Greek Conceptions of Heavy and Light

(i)

If we are to try to place Democritus' theory of weight, however briefly, in its proper context in the history of early Greek philosophy, and more particularly if we are to correct the influential but facile picture of early notions of weight offered by Burnet, so as to distinguish clearly between the Atomists' conception of weight and the necessary entailment of weight and movement that was later an integral part of Platonic and Aristotelean philosophy, we need first to return to the notion that movement and rest, for the Presocratics, formed part of a circle of associations that when Aristotle wrote were already outdated as a determinative force in philosophical thinking, and that even in Plato appear only, I think, as part of the conscious anachronism, in style and detail, of the *Timaeus*.¹

For the Presocratics, rest and movement were primarily associated with the opposition between unity and plurality, likeness and difference. For the Atomists, in particular, the movement of the atoms was probably sufficiently explained by, or perhaps sufficiently taken for granted as a concomitant of, their eternally pre-existing plurality and diversity.²

For Aristotle, these same associations are no longer viable. Unity and plurality, sameness and difference, in so far as they

¹ Cf. ch.XI § 2, pp.311–15 above. For Burnet's interpretation (*EGP* 341–7), see above pp. 175–7 and 359–63.

² Eternity, in some sense, is expressly stated by Aristotle as the *arche* of natural phenomena for the Atomists, and in that sense as providing a cause or explanation, or perhaps one should rather say as obviating any need for a cause: *Phys.* viii 1, 252a32–b5 (in part DK 68A65), *De gen. anim.* ii 6, 742b17–35 (amazingly not in DK: perhaps one of the most important passages for an understanding of Presocratic notions of causality), cf. Eus. *Praep. evang.* i 8.7 (DK 68A39).

(footnote continued on next page)

have not been altogether abandoned, are subsumed under the new oppositions of form and matter, and of potency and act. For the elements, and for the inanimate substances which are formed from them, movement and rest are now primarily the expression of weight, as defined by the theory of natural places for the elements. Thus at the very outset of his analysis of weight in book four of the *De caelo* Aristotle writes of his enquiry into the nature of things heavy and light as being 'proper' (οἰκεία) to the study of questions concerning movement, 'since things heavy and light are so called by their capacity for natural movement of some kind' (307b28–32).

There is a no less symptomatic preface to the longer of the two accounts of heavy and light in the *Timaeus*. Plato starts precisely by claiming that 'heavy and light may be explained most clearly if they are examined in conjunction with the nature of what is "above" and "below"' (62C3–4:

βαρὺ δὲ καὶ κοῦφον μετὰ τῆς τοῦ κάτω φύσεως ἄνω τε λεγομένης ἐξεταζόμενον ἂν δηλωθεῖη σαφέστατα

Plato continues (62C5–63A6) by isolating, and rejecting, the notion that there are in the universe two opposite places 'which divide the whole between them', a place 'below' to which anything moves which has any body or bulk, and a place 'above' to which things travel only involuntarily. The view which Plato rejects here is that expressed, many centuries later, by Simplicius, as τούτοις δὲ τὸ βαρὺ μόνον εἶναι δοκεῖ: on Democritus' theory, as seen from the point of view of Aristotle's philosophy, 'only what is heavy is thought to exist' (*De caelo* 712.30). In rejecting this view, Plato betrays that preoccupation with place which determines the orientation of his own conception of heavy and light, and that of Aristotle. For the purport of Plato's own theory is that earth or fire will be heavy or light in so far as a larger or smaller part of either element has the tendency to return to what we might think of as its parent body (cf. 63A6–E7).

Thus for all the criticism of detail and of expression which

(footnote continued from previous page)

My point here is briefly to emphasise that *what* is eternal is no less important as providing a satisfactory explanation of movement in the fifth century.

Again, Aristotle writes of void as cause, or perhaps more properly as condition, of movement in an atomist theory, *Phys.* viii 9, 265b23–9 (in part DK 68A58), cf. iv 8, 214b12–215a24 (not in DK). Void, for the Atomists, I would see as a concomitant, and as a necessary condition of, plurality.

Aristotle heaps on Plato's theory in the *De caelo*, Plato's theory is in its essentials similar to that of Aristotle, in that both philosophers think of heavy and light, not as being restricted to some intrinsic character or quality, but as the tendency of a body to move in a certain direction and to be located in a certain place.¹

The difference between this new alignment of interests and the older pre-Platonic conception of weight is stated explicitly by Plutarch at the end of his treatise *On the primal and essential nature of cold*. The question, which of the three elements, other than fire, is the primary repository of coldness, lends itself easily to the citation of pieces of Presocratic theorising, and from Plutarch's pen not all of this information is likely to have been culled at second hand. His concluding remarks therefore, despite the looseness of their attribution, carry considerable authority, *De primo frigido* 955B-C: οὐκ εὐδαίμονα κληῖρον ἀποφαίνονταξ.

We must recognise that the wise men and intellectuals of old set a gulf between terrestrial and celestial bodies: they did so however not because of the different places <that those bodies occupy>, as though <weighing them> on a balance, and examining <their movements> up and down; on the contrary, <in ancient times they distinguished the two kinds of element> by the difference in their <intrinsic> powers.

'Bodies that are hot and shining, and swift and light, they assign to the being φύσει that is deathless and endless.

'Bodies that are murky and cold, and slow <and heavy>, they declare to be the hapless lot of creatures who dwell in the shadow of death below.'

¹ I am touching here upon themes that will be of central importance to my later essays on Plato and Aristotle, which will include a detailed analysis of Aristotle's criticism of Plato. For the context of the quotation from Simplicius see above pp. 157–60.

These remarks of Plutarch are in themselves sufficient to dispel Burnet's imaginings. Not only does Plutarch evidently see no difference in kind between heavy or light and other traditional pairings of opposites, specifically including hot and cold. He states explicitly that for the early philosophers weight was seen as an intrinsic character or 'power', and was not defined in terms of 'places', as for Aristotle, nor regarded ὥσπερ ἐπὶ ζυγοῦ, πρὸς τὰ κάτω καὶ ἄνω βλέποντας, a fairly plain allusion to the use of the balance in the expression of Plato's theory of weight in the *Timaeus*, in the passage which I have cited (62C3–63E7).

(ii)

Plutarch's generalisation is confirmed when we turn to the fragments of, or reports on, individual philosophers. At the same time, we can glean from these a more precise idea of what kind of 'power' weight was thought to be.

Thus Parmenides describes the two principles which form the world of appearance as respectively (πυκινόν): weight is thereby aligned with density.

Virtually the same two points recur in Empedocles. In a criticism of Empedocles attached to his own analysis of *alloiosis* in the *De generatione et corruptione*, Aristotle lists the pairs of characteristics which Empedocles attached to fire and to earth, i 1, 315a 10–11 (not in DK): 'fire he says is white and hot, earth is heavy and hard' (λέγει τὸν μὲν ἥλιον λευκὸν καὶ θερμόν, τὴν δὲ γῆν βαρὺ καὶ σκληρόν). A moment or two before, Aristotle has himself quoted the verses describing sun and rain, or fire and water. By a rather remarkable chance, Simplicius happens to quote, in another context, the whole set of verses containing Empedocles' own account of the characteristic features, or products, of the

¹ Simpl., *Phys.* 31.4–7.

four elements. Thus we know that of earth Empedocles himself wrote, fr. 21.6:

ἐκ δ' αἴης προρέουσι θέλυμνά τε καὶ στερεωπά¹

Both adjectives are extremely unusual. βαρύ is again a word which is descriptive of density.³

The same two features recur with Anaxagoras. Thanks again to Simplicius, we have Anaxagoras' own account of the opposites that are separated out from the original mixture, fr. 12 *sub finem*: τὸ θερμόν καὶ ἀπὸ τοῦ ζοφεροῦ τὸ λαμπρόν καὶ ἀπὸ τοῦ διεροῦ τὸ ξηρόν.

'From the thinly-spread there is separated what is thick, from the cold the hot, from the dark the shining, from the wet the dry.'

In the doxographical compilation transcribed by Hippolytus, what are essentially the same pairings appear thus, *Ref.* i 8.2 (DK 59A42):
πρόσω τοῦ αἰθέρος ὀρμησαι .

¹ Simpl., *Phys.* 33.8ff., 159.13ff.

² *ECC* 266–7, 280.

³ In writing thus, I have supposed that Aristotle replaces στερεός, στερεότης etc.). But this may be too restrictive an interpretation of Aristotle's procedure. Possibly Aristotle's two adjectives are intended to correspond to Empedocles' two neologisms, without being intended to correspond exactly to a difference in meaning between them.

'And so the thick and damp, the dark and cold, and all things heavy, join together in the middle . . . while all the things opposed to these, the hot and the shining and the dry and the light, hasten far into the aether.'

There is no single expression in Anaxagoras for the phrase which Hippolytus tacks onto his first list of opposites: *ἄραιόν* (in the fragment quoted by Simplicius). Again therefore the reduction to later terminology. Again, the association or alignment of weight and density.¹

(iii)

On the other hand, in Hippolytus' account of Anaxagoras these opposites are treated cosmogonically, and are therefore aligned with position. The accounts of Parmenides' <θεῖς πᾶν> τὸ κοῦφον.

‘ἐνθ’ οὗτ’ ἡελίοιο δεδίσκεται ἀγλαὸν εἶδος
οὐδὲ μὲν οὐδ’ αἴης λάσιον γένος οὐδὲ θάλασσα’

οὐκ ἄνω τι τῶν βαρέων, οὐ κάτω τι τῶν κοῦφων

¹ The adjectives which differ, but which are obviously intended to correspond, are: *ἄραιόν/κοῦφον*, *ζοφερόν/σκοτεινόν*, *διερόν/ὑγρόν*. These changes afford a neat instance of the transformation of genuine fifth-century vocabulary into the standardised terminology of the doxographical tradition: cf. pp.307–10 and pp.343–4 above. For the inclusion of weight in Diogenes' report on Anaxagoras, see below p.378 n.3.

"Watch out, my friend: take heed lest you bring upon yourself the vision of that time of cosmic catastrophe, that terrifying discordancy that we read of in tradition; <for so it will be> if in one place you set apart all that is heavy, and in another place you set apart all that is light. "Then there is not seen the shining face of the sun, no nor the shaggy earth, nor sea", as Empedocles tells us. Earth had <then> no share in heat; water had no share in air; of heavy things none was aloft, and of light things none below.'¹

This association of weight and movement, or at least of weight and position, in Anaxagoras and in Empedocles, might perhaps seem to undo my earlier conclusion, drawn from Plutarch's remarks in the *De primo frigido*, and to act as confirmation of Burnet's thesis, that heavy and light relate to the behaviour of the elements, and are not an intrinsic character of whatever kind hot and cold were thought to be. We have in fact a number of seemingly disparate conclusions.

1. In Plutarch's *De primo frigido* there is a grouping of heavy and light with other traditional pairings of opposites, specifically including hot and cold, and with a fairly sharp denial that these opposites, for the 'intellectuals and wise men of old', were defined in terms of place or of direction.
2. On the other hand, in Empedocles and in Anaxagoras, heavy and light, in a cosmogonical context (if we may allow that term to include, for the moment, Empedocles' time of total Strife) are in fact related to place, and therefore, at least by implication, to movement in a specific direction.
3. At the same time, heavy and light (whether singly or jointly) are either aligned with density, as in Parmenides, or, in accounts of Anaxagoras and Empedocles, they are offered as a paraphrase of terms which describe density.

Thanks to Theophrastus, we can see that each of these seemingly disparate conclusions has a part to play in the Presocratic conception of weight. When he turns from his historical account

¹ For my interpretation of this passage in relation to Empedocles' system see especially *ECC* 31–6 and 147–54.

of theories of the faculty of sense to give a preliminary *aperçu* of earlier theories of the nature of objects of sense, Theophrastus writes, *De sens.* 59 (DK 68A135):
καὶ ἔτι. . . .

'When we turn to the objects of sensation, the others <i.e. apart from Democritus and Plato> fail to specify the nature of the sensibles and the kind of thing that each one of them is.

'Take first objects of sensation that fall within the province of touch: their ideas on heavy and light, and hot and cold.

'<All> they say, for example, <is> that what is rare and fine is hot, and that what is dense and thick is cold: that at least is the fashion in which Anaxagoras distinguishes air and aether.

'Heavy and light they also account for by more or less these same factors, and further by movements up and down.'

In this passage, Theophrastus states expressly that earlier philosophers attributed heavy and light to 'more or less the same factors' as those to which they attributed hot and cold, namely fine and rare and thick and dense, '*and further*' to 'movements up and down'. This is perhaps the clearest and most convincingly embracive statement of the position that we could hope for. Heavy and light were associated with movement, although not at all exclusively so. For at the same time they were treated like hot and cold: that is, they were ranked with, and were liable to be reduced to, differences of density.¹

¹ Stratton, 119, gives just the opposite sense by translating καὶ ἔτι as 'that is to say', and so treating differences in density and different directions of movement as a single kind of explanation. But that is clearly not the meaning of the Greek.

The verb that is to be understood in the final sentence that I have paraphrased

(*footnote continued on next page*)

This multiplicity of ideas is really no more, and no less, than we might have expected. There was no sudden and unseen revolution, hidden in the darkness before the dawn of Greek philosophy, as Burnet imagines. Heavy and light were seen as opposites not radically different from other sensible oppositions such as hot and cold, or bright and dark, and in particular they were seen as partly reducible to differences of density: what is heavy is thick and dense, what is light will be fine and rare. At the same time, especially in a cosmogonical or in some related context, heavy and light or dense and rare were associated with differences in position and with movement; but this was in no way that invariable and necessary entailment of weight and movement that was to be an essential and a deliberate feature of Aristotelean and Platonic philosophy.

(iv)

In the light of this conclusion, the final sentence of Theophrastus' main account of Democritus' theory of weight, which I quoted earlier, gains considerably in significance. 'In other places' Democritus 'says simply that what is fine (τὸ λεπτόν) is light'.¹

What I take to be one possible example of Democritus', or perhaps Leucippus', use of κοῦφον is happily preserved for us in the doxographical sources, if we compare the following two accounts.

1. Diogenes Laertius, ix 31 (DK 67A1): ἀλλήλοις καὶ ποιεῖν πρῶτόν τι σύστημα σφαιροειδές .

'There are so many of the particles that they cannot continue their circling movement without being driven off in one direction or another: consequently fine atoms are sieved out,

(footnote continued from previous page)

is perhaps not quite clear. It is easier to pick up τοῖς αὐτοῖς. The difference in meaning is marginal.

¹ *De sens.* 62 (DK 68A135), quoted p.116 above; for the translation cf. pp.131 and 256 n.3 above.

as it were, and make their way <back> into the space outside <the whirl>, while the atoms that are left behind stay together and as they become enmeshed with each other they move around together, and at the same rate as each other, so producing the first <primitive> structure to have the shape of a sphere.'

2. Aetius i 4 § 2 (DK 67A24): εἷς τε τὸ μετέωρον ἀνεφέρετο .

'When the atoms cluster together in one spot, whichever are the larger and heaviest ones settle down beneath all <the others>, as opposed to whichever atoms are small and round and smooth and slippery: these are squeezed out by the very process which brings the <other> atoms together, and are carried aloft into the upper region.'¹

These are fairly obviously intended to be the same two groups of atoms, although they are presented the opposite way round: sky and earth in Diogenes, earth and sky in Aetius. In Aetius the expression τὰ δὲ λοιπὰ in Diogenes. At the same time, Aetius' expression indicates fairly well that the opposing group of atoms should be

¹ For my paraphrase of the passage from Diogenes Laertius see above p.205. The point of διὰ τὸ πλῆθος I take to be that there are so many atoms shooting around that they cannot avoid becoming entangled with each other.

In the passage from Aetius I have followed Usener, *Epicurea* fr. 308, and DK 67A24, in writing μείζονα, βαρύτερα etc. as referring to atoms. For the equivalent discrepancy in texts from Epicurus and Simplicius, see pp.159–60 above.

The cosmogony recorded from Aetius is not ascribed to any specific thinker, but the form of my argument requires only that, at this point, the ideas in it should correspond to the passage quoted from Diogenes' *Life* of Leucippus—and this they obviously do.

accounted as light. In Diogenes' report the atoms in the opposing group are in fact designated precisely as λεπτά.

The same associations appear in the account of smell. Here what is rare or fine (πλήν τοσοῦτον, ὅτι τὸ λεπτόν ἀπορρέον ἀπὸ τῶν βαρέων ποιεῖ τὴν ὀσμὴν).

'Democritus did not trouble to mark off a separate definition for smell, except to note that what is fine makes a smell when it floats off heavy things.'¹

The converse association, of heaviness and 'thickening', appears in the account of the earth's formation, in Aetius, iii 13.4 (DK 68A95):
καὶ κουφότητα, πυκνωθεῖσαν δὲ τῷ χρόνῳ καὶ βαρυν-θεῖσαν καταστῆναι.

'Democritus says that at the beginning the smallness and lightness of the earth allowed it to wander about, but that it was thickened in the course of time and that once it had been made heavy it came to a halt.'²

These passages adequately illustrate the remark that 'in other places' Democritus 'said simply that what is fine is light'. But they do more. From his tone, Theophrastus is evidently not quite sure whether the association of lightness with, or its reduction to, density was intended to be the same as Democritus' more sophisti-

¹ This conjunction of ideas is not peculiar to Democritus. The equivalent association, of what is rare or fine (οὐκ ἀληθές <δὲ> οὐδὲ τὸ μάλιστα ὀσφραίνεσθαι τῶν κούφων).

² Dyroff changed μανότητα, *Demokritstudien* 35 n.8. Although this would add to my argument. I think Diels is perhaps right to treat the change as unnecessary.

cated theory of lightness as caused by a preponderance of void. What Theophrastus' earlier remark (cap. 59) shows, however, is that Democritus' association, or identification, of lightness with density is essentially a continuation of earlier ways of thinking, to which Democritus has given more formalised and more sophisticated expression by his distinction between atoms and compound bodies and by his deliberate adoption of void.

(v)

But perhaps the clearest illustration of Theophrastus' remark that 'elsewhere Democritus says that what is light is fine' (cap. 62) is provided by Theophrastus himself, not however in his account of the atomic theory of weight, but indirectly in a couple of remarks attaching to his reports on Democritus' theory of flavours and colours.

A passage quoted earlier from Aristotle's *De anima* tells us that fire, for Democritus, is made from small, round atoms.¹ A red colour, Theophrastus tells us in the *De sensibus*, is made from the same atoms as what is hot, except that for a red colour the atoms are larger (cap. 75). There is however a difference, Theophrastus continues, between what is red and what is bright or shining. Colours that are 'brightest' (... θερμόν γὰρ τὸ λεπτόν).

This passage needs to be compared with a detail from the analysis of flavours. I have already quoted Democritus' explanation of a tart or bitter flavour.² The small, sharp atoms which produce this flavour also produce a sensation of warmth, Theophrastus tells us, 'by making empty spaces: for what has most empty space is most inclined to grow hot' (cap. 65: κενότητα ἐμποιοῦντα· μάλιστα γὰρ θερμαίνεσθαι τὸ πλεῖστον ἔχον κενόν).

Now this last expression, τὸ πλεῖστον ἔχον κενόν, exactly repeats the formula which Aristotle uses, in the *De caelo*, to

¹ Arist., *De anima* i 2, 405a8–13 (DK 68A101); cf. pp.317–18 above.

² *De sens.* 65 (DK 68A135); cf. pp.320–1 above.

explain why fire, for the Atomists, is the lightest element, iv 2, 309a15–16: διὰ γὰρ τοῦτο καὶ τὸ πῦρ εἶναι φασὶ κορυφώτατον, ὅτι πλείστον ἔχει κενόν. 'And that is why fire they say is lightest, because it has most void.'¹

We have therefore the following highly significant conjunction of ideas. The formula which Aristotle attributes to the Atomists as the explanation of why fire is the lightest element is exactly repeated in Theophrastus' account of why things grow hot, in his report on the analysis of flavours; while later, in the analysis of colours, what is hot is identified with what is λεπτόν for the formula which describes lightness in terms of void.

Thus Theophrastus himself, in the continuation of his report on Democritus, neatly illustrates the ambiguity which he remarks upon in his account of heavy and light, between the definition of weight in terms of void and the description in terms of density—with the difference that the ambiguity recurs in the description not of weight but of temperature.

But this transposition, from weight to temperature, is precisely what we are led to expect from Theophrastus' earlier and more general remark that earlier thinkers explained heavy and light by 'more or less the same factors' as those they used to explain hot and cold: 'what is rare and fine is hot, and what is dense and thick is cold' (cap. 59).

The only surprise, for the modern critic, is that Democritus and Plato had appeared to be exempted from this criticism, on the ground that these two thinkers had alone 'provided a definition for each one of the sensibles' (*cf.* cap. 60–1). But what we see now, even more clearly than before, is that Democritus' 'definition' of weight does not exclude the association, common to those who failed to provide a definition of weight, whereby differences of weight and differences of temperature were alike ascribed to differences of density.

1. The ambiguity which Theophrastus remarks upon in

¹ For a preliminary analysis of the context of Aristotle's criticism, see above pp. 101ff.

his report on Democritus' theory of weight (cap. 61–2), between a definition in terms of the proportion of void and a description in terms of density, is exactly repeated in remarks which Theophrastus makes about the atomic theory of temperature in his analysis of flavours (cap. 65) and colours (cap. 75).

2. The explanation of 'growing hot' which Theophrastus provides in his account of Democritus' theory of flavours (cap. 65) exactly repeats the definition which Aristotle attributes to the Atomists of fire as the 'lightest' body (*De caelo* iv 2, 309a15–16).¹

(vi)

Thus the general message is unmistakably clear. It is not true, as Burnet claims, that heavy and light were thought of as in some way radically different from other oppositions, including hot and cold. On the contrary, heavy and light, no less than hot and cold, for Democritus as for other Presocratics, were reducible to, and were explained by, differences of density, at least with regard to the nature of compound bodies. The difference between Democritus and the other Presocratics will presumably lie in Democritus' conjunction of the explicit admission of void with his conception of a single kind of material substance—the atoms—which are invariable in density.

This at least would explain, in part, Aristotle's remark in the *De caelo* that 'some of those who deny the void gave no definition of heavy and light, as is the case with Anaxagoras and Empedocles' (iv 2, 309a19–21). The point is not that Democritus' predecessors

¹ The priority which Theophrastus gives to the definition of temperature (cap. 59) is reflected in Aristotle's remark in the *Metaphysics*, quoted earlier, where Democritus' approximation to a definition of hot and cold is singled out as the lone precursor, among the writings of the 'physical philosophers', to Socrates' search for general definitions (*Met.* M 4, 1078b12ff., esp. b19–20; cf. p.338 n.1 above). Theophrastus' claim that the Atomists treat hot and cold as ἀρχαί presumably reflects the same idea (*De sens.* 71). The priority of hot and cold in relation to the other sensibles perhaps helps to explain the leading rôle given to temperature in Aristotle's criticism of Democritus in the passage from the *De generatione et corruptione* analysed in my second chapter (i 8, 325b36–326a14, see pp.57ff. above).

failed 'to give any explanation' of weight 'at all, *or even* to say anything about it', as Burnet supposes.¹ Only the first part of the sentence is true. Anaxagoras and Empedocles failed to define heavy and light, but as Aristotle remarks at the beginning of book four of the *De caelo* 'everyone uses the powers' of heavy and light 'although few people have defined them' (iv 1, 308a3–4).²

This is essentially Theophrastus' point. Anaxagoras is specified as having distinguished hot and cold by variations in density (*De sens.* 59). But Theophrastus evidently does not count a variation in density as sufficient for an explanation or a definition of hot and cold, for Anaxagoras' account of hot and cold, in this chapter of the *De sensibus*, is introduced precisely to exemplify those who 'fail to specify the nature of the sensibles'. The same will be true for Anaxagoras' use of heavy and light. I have already noted the way in which Anaxagoras' own distinction between 'thick' and 'thin' appears in the doxographical summary recorded by Hippolytus as a distinction between 'thick' or 'heavy' and 'light'. Presumably therefore Anaxagoras will be included among those whom Theophrastus writes of in this same chapter of the *De sensibus* as accounting for heavy and light by 'the same things' that they used to account for a difference of hot and cold, namely variations in density (cf. τοῖς αὐτοῖς, cap. 59). But again the association of heavy and light with a variation in density is introduced precisely to exemplify those who 'fail to specify the nature of the sensibles'.

Democritus and Plato are excepted from this criticism, by both Aristotle and Theophrastus. But this need not mean—and the point about τὸ λεπτόν indicates that it does not mean—that Democritus therefore has some radically new and exclusive conception of the nature of weight. The point would appear to be rather that Democritus' essential step is to place the old conception of heavy and light as distinguished by density on what Aristotle and Theophrastus recognise as a new and so to speak scientific or philosophical footing.³

¹ EGP 342 (my italics), quoted in context pp.175–6 above.

² The detailed interpretation of this passage must await my third essay. Meanwhile cf. ECC 34–6.

³ I have taken Anaxagoras to represent the 'old' conception of heavy and light, despite the account that is given of his theory by Diogenes. In Diogenes' report, ii 8 (DK 59A1), the string of opposites which we find in fr. 12 and in Hippolytus (cf. pp.368–9 above) is reduced to 'heavy' and 'light', exemplified

(footnote continued on next page)

(vii)

From one point of view the change has been a simple and an obvious one. The material component of Democritus' world, the atoms, are no longer subject, individually, to changes in density. If one atom can no longer be heavier or lighter than another because it is more dense or more rare, if it is impossible, so to speak, to stuff more material into the same volume, then an increase of weight can only, or at least most obviously, be achieved by an increase of size. From this point of view, the association of heavy and light with dense and rare is transferred, in the atomic system, to an alignment of heavy and light with large and small: weight becomes a function of size.

But that is only part of the story. The direct association of heavy and light with differences of density continues, in the account that Democritus gave of bodies compounded of atoms and void. From this point of view, we have to turn the evidence on its head, so to speak. I have spent most of this essay attempting to disentangle the evidence for the weight of the individual atoms: for the evidence on the weight of compound bodies, in the *De caelo* and in Theophrastus, is less controversial, except perhaps for the question of the difference, or the lack of difference, in volume between the bodies compared. But as often the difficulty in disentangling the evidence is not proportionate to the importance of the question. When Simplicius writes that the atoms are

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by earth and by fire, with water and air offered as intermediate elements, all precisely as in Aristotle's scheme.

Scholars have siezed upon this report as evidence of Anaxagoras' 'anticipation' of Aristotle's view, most notably and most recently W.D. Ross, in the introduction to his edition of Aristotle's *Physics*, 26 n.2. This, I am afraid, is not untypical of the rather mechanical fashion in which Ross introduces material from *Die Fragmente der Vorsokratiker* into his commentaries on Aristotle. For the truth is much more likely to be the other way round: that the traditional listings of opposites which we find in fr. 12, and which have already been partly Aristoteleanised, or so I have argued, in Hippolytus, have now been dressed up to look wholly like Aristotle by Diogenes or his source. This at least would seem to be the conclusion indicated (1) by Aristotle's own remark that 'some of those who deny the existence of void, such as Anaxagoras and Empedocles, have given no definition of heavy and light' (*De caelo* iv 2, 309a 19–21), and (2) by Aristotle's statement that Empedocles was the first to use four elements simultaneously (*Met.* A 4, 985a31–3), coupled with my conclusion that Anaxagoras wrote before Empedocles (cf. 'The relation of Anaxagoras and Empedocles', *JHS* 88 [1968] 93–113).

'causes of heaviness in compound bodies, just as void <is cause> of lightness' (*De caelo* 269.13–14), his language in part reflects the Aristotelean notion of heaviness and lightness as distinct and opposite principles. But the remark that the atoms 'in virtue of being full <or dense> do themselves have heaviness and are <thereby> causes of heaviness in compound bodies' (269.12–13) does perhaps correctly reflect one preoccupation in the original theory: the atoms have heaviness in order to account for the density, and the heaviness, of the compound bodies, which alone fall directly within our perception.¹

And from this point of view we arrive at the same conclusion, only by a different route, so to speak. If Democritus is to continue the traditional association of heavy and light with dense and rare, and more particularly if atoms are to act with void as a coordinator of the weight of compound bodies, then a difference of size in the atoms cannot but find expression in a difference of weight: more and smaller atoms will give the same proportion of solid to void as fewer and larger atoms. The individual atom must therefore again be reckoned as having weight in proportion to its size.

But this way of looking at Democritus' theory, though I think in one sense legitimate, in another sense acts only to cast the burden of explanation from one factor in Democritus' theory to another. It is more important, I think, to appreciate that the preoccupation with density, and thereby with the size and with the weight of individual atoms, is not dependent upon any notion of weight as, to repeat the expression of Professor Kirk, 'a tendency to move consistently in a certain direction'.² On the contrary, if the individual atoms are to be distinguished, apart from the role that they play in the composition of cosmic bodies, by their speed or by their force of impact in the void, then the early conception of weight as related primarily to density, and only in part to 'movements up and down', will not require the speed of atoms that are moving in a void to be attached to the notion of movement in a specific direction, nor will impact, as in Epicurus' system, need to be subordinated, so to speak, to any notion of a 'fall' of atoms. From this point of view the essential move will be

¹ The passage in Simplicius has been considered, ch. V § 2, pp. 161–6 above.

² *Presocratic philosophers* 415, cf. p. 363 above.

to rid our minds equally of weight as tied primarily to movement in a specific direction within a cosmos, and of its converse, the notion of weightless bodies in a vacuum. If heavy and light are not defined primarily in terms of movement up and down within a cosmos, then bodies outside a cosmos will be liable to retain their differences of weight no less than their differences of size.

(viii)

I return therefore to the passage in Theophrastus: the notion of differences in density and of 'movements up and down' as the *two* criteria of weight in early Greek thought. In this disjunction and association of ideas I think we see most clearly the continuity and the difference between early Greek conceptions of heavy and light, as epitomised by Democritus, and the later Platonic and Aristotelean conceptions of weight.

Democritus and Plato are singled out by Theophrastus as having alone provided an explicitly philosophical theory, a 'definition', of the nature of *sensibilia*, explicitly including weight, *De sens.* 59–60 (DK 68A135): γὰρ ἀφορίζουσι.

'The others leave out any account of the objects of sense. . . . Democritus and Plato are the only ones who have really come to grips with the subject. They advance a definition for each one of the sensibles.'

As I have noted, there is much the same implication in the equivalent remark in the *De caelo*, that those who denied the existence of void, Anaxagoras and Empedocles, gave no definition of weight. If only in the light of what Theophrastus says, we must, I think, treat the theory of weight as defined by 'largeness and smallness' which Aristotle regularly introduces alongside Plato and Democritus in the fourth book of the *De caelo*, but without attaching it to any named philosopher, as in large part Aristotle's own elaboration of the assumptions about weight which he held to be implicit in the theories of Democritus and of Plato.¹

¹ I explore this point in my third essay, where I argue that the 'third' theory is also in part Aristotle's extrapolation from Ionian ideas.

If therefore we restrict the field of early definitions of weight to Plato and Democritus, we find that the philosophical explication of early notions of weight follows a type that is at once familiar to those with an eye for a characteristic mode in the development of philosophical ideas. In the earlier fifth century two conceptions of weight exist side by side.

1. Weight is no different in type from hot and cold: like them it is associated with, or even in some sense reducible to, density.
2. At the same time, light and heavy are associated with the behaviour of things: with their movement and with their position.

Philosophical reflection singles out first one and then the other of these two conceptions.

1. The association of weight with density is adopted by the Atomists to form the basis for what is probably the first explicitly philosophical explanation of weight.
2. The latter association is developed into a Platonic or Aristotelean theory of natural places for the elements, with heavy and light tied to the notion of movement in a specific direction.

Admittedly, these are not exclusive associations, on either side.

1. Movement towards a specific place has its footing in the theory of Democritus. Large atoms, and dense agglomerations of atoms, when they are drawn into a cosmos, will move towards the centre, while small atoms, and rarefied agglomerations of atoms, are squeezed out and forced towards the circumference, or beyond.
2. From the other point of view, although Plato's definition of weight as determined by resistance is preceded by a sophisticated analysis of the notion of place and direction, nonetheless Plato also includes in his theory, I shall argue, the older conception of weight as determined by size and by density.
3. Equally, in Aristotle's theory, the difference between

heavy and light in fact goes hand in hand, we learn in the *Physics*, with a difference of density, although a reading of book four of the *De caelo* leaves no doubt that it is place and position which are the determinative forces in Aristotle's conception.¹

With these qualifications, it remains true that density, or size and density, are the primary determinants of the earlier conception of weight, as expressed most directly by Democritus, while for Democritus, as for other of the Presocratics, the distinction of place is secondary and derivative, whereas for Aristotle it is place and position that are primary.

The question of the order in which these two conceptions of weight were distinguished, why the association with density should have developed earlier than the association with place, veers off into larger questions of ontology. Democritus, with no single nor eternal world, would scarcely have been able to define the weight of his ultimate elements in terms of their location within the transitory phenomena of sky and earth. The atoms therefore must contain within themselves whatever character is peculiar to their existence. On the other hand, in a world that is single and eternal, as for Plato and for Aristotle, centre and circumference are the more able to act as a permanent reference for, and therefore as sufficient explanation of, the nature of the substances that habitually find themselves located there.

¹ I leave these two points (cf. *Phys.* iv 9, 216b22–217b20) for analysis in my third essay.

BIBLIOGRAPHY

I have not attempted to produce a complete bibliography of modern critical works on topics touched upon in the course of this study. The following list contains therefore (1) all works that for any reason have been cited in the text or in the footnotes, and (2) a few other works that I have consulted, and that I have found significant or even useful, but that I have not had occasion to refer to. Some broader works on the history of the subject I am keeping for the Bibliography to my fourth volume, unless they happen to have been referred to in the course of the present work.

In general my aim has not been to deal exhaustively with previous literature, but to take only those interpretations that have been most influential or that seemed most worthy of consideration, and then to deal with these interpretations fairly fully, at the cost of cutting out references to less well-known and to less influential works of criticism. I have hoped thereby to gain in clarity and in continuity of thought, although it is not without some regret, and hesitation, that I have abandoned the completeness of reference, and detail, that I had aimed at in some of my earlier publications.

Entries are arranged alphabetically under authors' names. I have tried to include all details for the reprinting of articles, but I have usually included the reprinting of books only when significant additions or changes have been made to the text. Where relevant, references are given at the end of an entry to the pages of the present work on which the items in question have been cited.

I have sometimes added brief critical notes; in one or two cases I have used the Bibliography as a place to explain why some items are not dealt with more fully in the text.

ALFIERI Vittorio Enzo. *Gli Atomisti, frammenti e testimonianze, traduzione e note di V.E.A. Guis*. Laterza & Figli, Bari. 1936. Pp.xviii + 410.

172 n.1. 186 n.2. 203 n.3. 285 n.4. 326 n.1. See also HAMMER-JENSEN (1910) in the Bibliography.

ALFIERI Vittorio Enzo. 'La formazione del pensiero aristotelico e la polemica epicurea', *Sophia, rivista internazionale di filosofia e storia della filosofia* [this subtitle varies sometimes between different issues] 7 (1939) 221–44.

187 n.4.

ALFIERI Vittorio Enzo. *Atomos idea, l'origine del concetto dell'atomo nel pensiero greco*. Felice le Monnier, Firenze. 1953. Pp.vii + 214.

After a rather wordy argument, with a partial and somewhat unsystematic use of evidence, 80–95, Alfieri concludes, 93:

'Il peso opera non quale forza di caduta, come fraintendevano Epicuro e Lucrezio, bensì quale forza vettoriale, verso quella direzione che è determinata dal rapporto delle forme affini e dalla loro vicinanza, e con velocità proporzionale al peso.'

154 n.1. 186 n.2. 187 n.4. 285 n.4. 324 n.1.

ARCHER-HIND Richard Dacre. *The 'Timaeus' of Plato edited with introduction and notes*. MacMillan and Co., London and New York. 1888. Pp.vii + 358.

xvii–xviii.

ARRIGHETTI Graziano. *Epicuro opere a cura di A.G.*, in the series *Biblioteca di cultura filosofica* no. 41. 1st edn 1960. 'Nuova [2nd] edizione riveduta e ampliata'. Giulio Einaudi editore, Torino. 1973. Pp.liii + 793.

285 n.3.

ASULANUS. I have consulted the text of Asulanus' Latin translation of the *De generatione et corruptione* in the version attached to Averroes' works, published Venetiis 1483. The same or a similar translation is contained in an earlier edition, Patavii 1474. Both works are in the Bibliothèque Nationale, Paris, respectively: Rés. R 355 and Rés. R 357.

The former work has for colophon: *nove translationi librorum de generatione et corruptione ab Averi Cordubensi commentate . . . finis impositus est. Impensa atque diligentia Andree de asula Venetiis impresse. Anno salutis christiane M CCCC LXXXIII septimo calendas octobris.* (Hain, *Repertorium bibliographicum* 1660.)

The latter work has for colophon: *nove translationi librorum de generatione et corruptione ab Averi Cordubensi commentate . . . finis impositus est. Nobilis vicentini Ioannis philippi Aureliani et fratrum impensa. Opera vero: atque ingenio Laurentii Canozii Lendenariensis. Impresse Patavii Anno Christi optimi M CCCC IIII et LXX quarto decimo kalendas Iulii.* (Hain, *Repertorium bibliographicum* 1691.)

64–5. 75–6.

AUBENQUE Pierre. 'Physique aristotélécienne et langage', *Archives de philosophie, recherches et documentation* 31 (1968) 125–32.

A useful corrective to WIELAND's account of the kind of analysis to be found in Aristotle's physical writings.

xix n.1.

BAEUMKER Clemens. *Das Problem der Materie in der griechischen Philosophie, eine historisch-kritische Untersuchung*. Druck und Verlag der Aschendorffschen Buchhandlung, Münster. 1890. Pp.xv + 436.

A repetition of Zeller's view, 82–3 and 94–5.

BAILEY Cyril. *Epicurus, the extant remains, with short critical apparatus, translation and notes*. Clarendon Press, Oxford. 1926. Pp.432.

4–5. 160 n.4. 184 n.1. 231 n.1. 285 n.4. 289 n.2. 290 n.4. 295.

BAILEY Cyril. *The Greek Atomists and Epicurus, a study by C.B.* Clarendon Press, Oxford. 1928. Pp.viii + 619.

Despite the virtues of Bailey's work on Epicurus, readers of this later study, and especially of the pages on weight and movement, 123–48, *cf.* 82–4, should be on their guard against misinterpretations, and even mistranslations, of the evidence, only some of which I have singled out for attention in the course of my essay.

4–5. 8 n.1. 46 n.3. 54 n.1. 137–8. 140–2. 148–9. 154 n.1. 158–61. 177 n.4. 186. 203 n.3. 224–6. 231 n.1. 232 n.2. 245 n.1. 248 n.1. 264–6. 269 n.2. 284 n.3. 287 n.3. 294–5. 296–7. See also BOLLACK (1969) in the Bibliography.

BALDES Richard William. *Aristotle's relation to Democritus reconsidered and vindicated as against the criticism of Harold Cherniss*. Dissertation . . . in the department of classical studies of Loyola University, Chicago. 1972. Typescript, pp.332.

A useful check on Cherniss' treatment of Aristotle: the problem of weight is not discussed.

BEARE John Isaac. *Greek theories of elementary cognition from Alcmaeon to Aristotle*. Clarendon Press, Oxford. 1906. Pp.vii + 354.

BIGNONE Ettore. 'Epicurea', *Atti della r[eale] Accademia delle scienze di Torino* 47 (1911–12) 670–90.

293 n.1.

BIGNONE Ettore. *L'Aristotele perduto e la formazione filosofica di Epicuro*, in the series *Il pensiero classico* no. 4. 'La nuova Italia' editrice, Firenze. 2 parti, 1936. Parte i, pp.xvii + 410. Parte ii, pp.633.

187 n.4.

BIGNONE Ettore. 'La dottrina epicurea del "clinamen", sua formazione e sua cronologia, in rapporto con la polemica con le scuole avversarie, nuove luci sulla storia dell'atomismo greco', *Atene e Roma* serie 3 anno 8 (1940) 159–98.

187 n.4.

BOLLACK Jean. 'Deux figures principales de l'atomisme d'après Aristote: l'entrecroisement des atomes et la sphère du feu', *Symposium Aristotelicum* 4 ed. I. During (Heidelberg, 1969) 32–50.

This study contains several remarks on the nature of weight. Bollack at first states clearly, 39 n.39: 'Les atomes ne pèsent pas'. Later however he appears to qualify this in the way that Burnet does. Thus having quoted both Aetius' denial that the atoms have weight, and Aristotle's assertion in the *De generatione et corruptione* that 'each atom is heavier according to its preponderance', he writes, 46 n.77: 'Dans le monde, le plus lourd, pour Démocrite, est le plus grand; donc les atomes, quand ils étaient plus grands, devaient être plus lourds'. In the following note, 47 n.78, he continues: 'Le poids se dégage de la grandeur relative, une fois les corps rassemblés'. Later, 48 n.84, he qualifies Simplicius' attribution of weight to the atoms in virtue of the uniformity of their nature (*De caelo* 569.5–9, pp.154–7 above) as applying 'dans le monde des choses devenues'.

I have therefore thought myself justified in speaking of Bollack's interpretation as a version of Burnet's view (p.154 n.1 above).

However, in the note that I first quoted, 39 n.39, Bollack continues: 'Il est certain qu'après les analyses d'Aristote . . . la grandeur des atomes peut s'exprimer en poids. Les atomes seraient plus lourds, si l'on peut dire, *dans l'ordre intelligible*, quand ils excèdent par leur volume' (my italics).

The phrase that I have italicised is perhaps explained by Bollack's odd notion that 'les atomes, par eux-mêmes, sont immobiles' (p.46 n.75). There is the same curious notion in Pillon and Bailey (see pp.224–6 above). With Bollack, the idea results from—to my mind—a blatant misinterpretation of *De gen. et corr.* i 8, 325a2–16 as an account of Leucippus' own acceptance of Eleatic arguments, and not as Aristotle's account of the *impasse* in Eleaticism from which Leucippus thought that he had found a successful escape (*cf.* 325a23–b11: Bollack, 34–42).

This line of thinking comes to the fore in the final pages of Bollack's article, promisingly introduced by the remark, 46: 'On a longtemps échangé les arguments sur ce point, qui paraissait obscur, de la relation qu'entretiennent le poids et le mouvement des atomes'. The solution which Bollack offers springs from a further misunderstanding of a text in Aristotle, where ἡ ὑστερίζον ἢ ἐκθλιβόμενον (*De caelo* 310a10, *cf.* p.328 n.1 above) is taken not as alternative descriptions of how, in the atomist system, or elsewhere, according to Aristotle, things appear to be light, but as complementary descriptions of earth and fire, whereby fire 'semble léger parce qu'il délimite et circonscrit le lourd qu'il abandonne à sa lourdeur' (p.48). This leads to some characteristic rhetoric on the sphere of fire, 49–50:

D'une part, elle représente, dans l'antithèse éléatique, la plénitude de l'être en face du vide . . . Seule, elle est pleinement elle-même face aux corps qui l'entourent. . . . Le feu introduit la pulsation régulière et l'ordre du temps. Le cercle qui limite le système cosmique est issu de sa sphéricité. . . .

'Ce que la sphère représente en tant que forme et en tant qu'idée, commande à un autre niveau, dans la physique, ce qu'elle accomplit en tant que corps. Cette cohérence, ces correspondances qui structurent et confondent l'ordre intelligible et le monde des corps s'opposent absolument à l'arbitraire et à l'enchaînement aveugle que désigne l'étiquette mécaniste que l'on applique à Démocrite.'

Despite the criticism of my conclusions and my methods that have been lavished on me by Professor Bollack and by his pupil and collaborator M. Wismann, I can only honestly repeat what I wrote in my earlier study on Empedocles (*ECC* 161): this kind of language seems to me quite unprofitable for

the study of a Presocratic—even Empedocles, and perhaps more especially Democritus.

154.n.1. 171 n.1.

BOLLACK Jean, BOLLACK Mayotte, WISMANN Heinz. *La lettre d'Epicure* [i.e. the *Letter to Herodotus*, text, translation and notes] in a series *Le sens commun*. Les éditions de minuit, Paris. 1971. Pp.312.

326 n.1.

BOLLACK Mayotte, see under BOLLACK Jean.

BONITZ Hermann. *Index Aristotelicus*, in *Aristotelis opera*, ed. Academia regia Borussica, vol. v. Berolini, typis et impensis Georgii Reimeri. 1870. Pp.viii + 878.

45 n.1. 133 n.1.

BORICEVSKIĬ I.A. 'Demokrit und Epikur im Kampf um die Grundlagen des Atomismus' [in Russian with an abstract in German], *Archive for the history of science and technology* [in Russian], series 1, number 8 (1936) 111–36.

359 n.1.

BOSSIER F. and STEEL C. 'Tekststudie: Priscianus Lydus en de *In de anima* van Pseudo(?)-Simplicius', *Tijdschrift voor Filosofie* 34 (1972) 761–822.

226 n.1.

BRIEGER Adolf. *Die Urbewegung der Atome und die Weltentstehung bei Leucipp und Demokrit*, in *Jahresbericht des Stadtgymnasiums zu Halle A/S von Ostern 1883 bis Ostern 1884*. Druck der Heynemannschen Buchdruckerei, Halle A/S. 1884. Pp.28.

This is a careful and useful work, which fails fully to resolve the questions which it touches upon because of an over-preoccupation with refuting the thesis of Zeller on the downward movement of Democritus' atoms. Thus having shown that the atoms do not move downwards in the void Brieger fails to retrace his steps and to think through fully the implications of his new thesis for the evidence on weight.

The work is in two sections, (1) 'Die Urbewegung der Atome' (pp.3–13), and (2) 'Kosmogonie' (pp.13–28). The arguments of the first section are repeated in 1904: see the entry immediately following.

44. 46 n.3. Ch.IV § 1, 118–31. 137–8. 156 n.1. 159. 160–1. 163. 171–2. 175. 189. 228 n.2. 242. 243. 260 n.1. 262. 269 n.2. Ch.X § 2, 270–9. 279 n.3. 290. Ch.XIII § 1, 347–64, esp. 351–60, 363–4.

BRIEGER Adolf. 'Die Urbewegung der Demokritischen Atome', *Philologus* 63 n.F. 17 (1904) 584–96.

This is a re-handling of arguments put forward in 1884, without any really new orientation on the relation of weight and movement.

43–5. 137–8. 156 n.1. 160–1. 163. 171–2. 175. 189. 203. 228 n.2. 243. 262. Ch.X § 2, 270–9. Ch.XIII § 1, 347–64, esp. 355–60, 363–4. See also HAMMER-JENSEN (1910) in the Bibliography.

BURCHARD Johann Friedrich Wilhelm. *Commentatio critica de Democriti Abderitae de sensibus philosophia*, under the superscription *Ad sollemnia saecularia Scholae Mindensis ante hos CCC annos inauguratae . . .* A second title: *Democriti Abderitae philosophiae de sensibus iisque quae sensibus percipiuntur fragmenta e Theophrasti eiusdem argumenti libello, maximum partem deperdito, eruere et interpretari conatus est J.F. G.B. Mindae*, typis F.G.H. Muelleri. 1830. Pp.41.

Theophrastus *De sensibus* 61–2 is contained in § 5, pp.14–16 and 29–30.

Ch.IV § 1, 116–31, esp. 119–21.

BURNET John. *Early Greek philosophy*. 1st edn 1892. 2nd edn 1908. 3rd edn 1920. 4th edn, a reprint of the 3rd edn. A. and C. Black, London. 1930. Pp.vii + 375.

Burnet's account of weight does not appear in the first edition (1892). It is contained only in the second edition (1908) 394–401, whence it is repeated largely unchanged in the third edition (1920) 341–7.

xvi. 8 n.1. 43–4. 46 n.3. 153ff. 163. 171–2. Ch.VI § 1, 174–82, esp. 175–7. Ch.VII §§1–2, 203–10, esp. 207–10. Cf. 212–13. 223 n.1. 255. 264. 299–302, 314 n.2. Ch.XIII § 1, 347–64, esp. 359–64. 372. 377–8. See also HAHM (1976) and HAMMER-JENSEN (1910) in the Bibliography.

BURNET John. *Greek philosophy part I Thales to Plato* (no more published). MacMillan and Co., London. 1914. Pp.x + 360.

This repeats, 96–101, essentially the account of 'Democritus' theory in *EGP* 2nd edn 394–401 (= 3rd edn 341–7).

153 n.2.

CAPONE-BRAGA Gaetano. 'Aristotele, Epicuro e Diogene di Enoanda', *Atene e Roma* serie 3 anno 8 (1940) 35–47.

163 n.1. 187 n.4.

CARTERON Henri. *La notion de force dans le système d'Aristotele*. Librairie philosophique J. Vrin, Paris. 1923. Pp.xi + 281.

88 n.1.

CHERNISS Harold Fredrik. *Aristotle's criticism of Presocratic philosophy*. The John Hopkins Press, Baltimore. 1935. Pp.xiv + 418.

In the sections of my study devoted to Aristotle, I have tended to concentrate my criticism on the relevant parts of Cherniss' work, 96–100 and 204–13, both because of the potential importance of its thesis, and because of the influence which it has won. In fact it seems to me that Cherniss' work, welcome though it is for its accumulation of material and for its exhaustiveness, is unsound on many points of detail. This is not of course to deny that Aristotle's accounts of, and allusions to, his predecessors are influenced at almost every turn, both consciously and no doubt on a less conscious level, by his own categories and his own ideas: but the nature and the extent of this influence is in my view often oversimplified by Cherniss, and sometimes grossly so. However, I add these remarks here only as a passing caution: in the body of the work I have limited my criticism of Cherniss strictly to the matter in hand.

xv–xvi. Ch.I § § 2–5, 6–40, esp. 7–11, 14–15, 16–18, 40. 46–8. Ch.II § 2, 49–57. Ch.III § 1, 81–100, esp. 94–7. 112–14. 303 n.1. 351.

CHERNISS Harold Fredrik. *Aristotle's criticism of Plato and the Academy*. The John Hopkins Press, Baltimore. 1944. Pp.xxvi + 610.

xv–xvi. xviii.

COOPER Lane. *Aristotle, Galileo and the tower of Pisa*. Cornell University Press, Ithaca, New York. Oxford University Press, London. 1935. Pp.102.

187 n.4.

CORNFORD Francis MacDonald and WICKSTEED Philip H. *Aristotle* vols iv–v, *The 'Physics' with an English translation by P.H.W. and F.M.C.*, in the *Loeb classical library*. W. Heinemann, London. Harvard University Press, Cambridge, Massachusetts. 2 vols, 1929–34, vol. i 'revised and reprinted' 1957. Vol. i, pp.xciv + 427. Vol. ii, pp.xii + 440.

187 n.4.

CORNFORD Francis MacDonald *The laws of motion in ancient thought, an inaugural lecture by F.M.C.* The University Press, Cambridge. 1931. Pp.47.

177 n.2.

COUTANT Victor. *Theophrastus 'De igne', a post-Aristotelian view of the nature of fire, edited with introduction, translation and commentary by V.C.* Royal VanGorcum Ltd, Assen. 1971. Pp.xxvi + 72.

131 n.1.

DELLING Gerhard. 'Zum steigenden Gebrauch von Komposita mit ὁπέρ bei Paulus' *Novum testamentum* 11 (1969) 127–53.

44 n.1.

DENNISTON John Dewar. *The Greek particles*. 1st edn 1934. 2nd edn 1954, with corrections 1966. The Clarendon Press, Oxford. Pp.lxxxii + 660.

77 n.1. 128 n.1.

DESCARTES René. *Principia philosophiae*, in *Oeuvres de Descartes*, publiées par Charles Adam et Paul Tannery. Léopold Cerf imprimeur-éditeur, Paris. 12 tomes, 1897–1910. Latin version: tome viii, 1ère partie, 1905. Pp.xviii + 348. French translation: tome ix, [2ème partie,] 1904. Pp.xx + 358.

349–50. Cf. 341 n.1. Cf. 361 n.1.

DIELS Hermann. *Doxographi graeci, collegit recensuit prolegomenis indicibusque instruxit H.D.* Berolini, typis et impensis G. Reimeri, 1879. Pp.x + 854.

4 n.1. Ch.IV § 1, 116–31. 133 n.1. 223 n.1. Cf. 260 n.1. 281 n.2. 282 n.1. 287–8. 298. 300 n.1. 301 n.1. 373 n.1. 374 n.2.

DIELS Hermann. Edition of Simplicius' *Physics*, in the collection *Commentaria in Aristotelem graeca*, vols ix–x. Berolini, typis et impensis G. Reimeri. 1882–1895. Vol. ix, pp.xxxi + 800. Vol. x, pp.xiv + 801–1463.

169–71. 193. See also the Index Locorum.

DIELS Hermann. *Die Fragmente der Vorsokratiker, griechisch und deutsch von H.D.* 1st edn 1903. The pagination is unchanged from the 5th edn by Walther Kranz. Weidmannsche Verlagsbuchhandlung, Berlin. 3 Bände, 1934–7. Band i, pp.xi + 482. Band ii, pp.416. Band iii, pp.651. There are a number of *Nachträge* in the later editions.

378 n.3. Cf. 364 n.2. Passages with cross-references to 'DK' are not repeated here.

DIELS H. 'Aristotelica', *Hermes* 40 (1905) 301–16.

169–71. 193.

DÜRING Ingemar (ed.) *Naturphilosophie bei Aristoteles und Theophrast, Verhandlungen des 4. Symposium Aristotelicum veranstaltet in Göteborg, August 1966, herausgegeben von I.D.* Lothar Stiehm Verlag, Heidelberg. 1969. Pp.292.

Apart from a reference to Düring's own 'Zur Einführung', 7–17, contributions are listed separately under their authors' names: see BOLLACK, FURLEY. GIGON. VERDENIUS.

4 n.1.

DYROFF Adolf. *Demokritstudien*. Dieterich'sche Verlags-Buchhandlung, Leipzig. 1899. Pp.188.

Although Dyroff's discussion of weight, 31–9, concludes by being unduly negative, it contains nonetheless many useful points of detail, and is especially noteworthy for attempting to place Democritus' conception of weight in its historical setting.

5 n.1. 8 n.1. 42ff. 50ff. 61–2. 256 n.4. 357–60. 374 n.2.

EICHHOLZ David Edward. *Theophrastus 'De lapidibus', edited with introduction, translation and commentary by D.E.E.* Clarendon Press, Oxford. 1965. Pp.vi + 141.

131 n.1.

ELDERS Leo. *Aristotle's cosmology, a commentary on the 'De caelo'*, in the series *Philosophical texts and studies* no. 13. Van Gorcum and Company, Assen. 1966. Pp.370.

88 n.1.

ENRIQUES Federigo and MAZZIOTTI Manlio. *Le dottrine di Democrito d'Abdera, testi e commenti*. Nicola Zanichelli editore, Bologna. 1948. Pp.xxii + 339.

The section entitled 'Peso e gravitazione', 62–6, starts off by endorsing Burnet's interpretation, and then, under the influence I think of Löwenheim (who is not acknowledged, but who is included in the bibliography), suggests that Democritus may have believed in the universal attraction of matter:

'Non troviamo dati della dossografia che permettano di attribuire a Democrito una tale ipotesi; ma non si può escludere che egli si accostasse ad una qualche intuizione della cosa' (pp.65–6).

154 n.1.

ERDMANN Johann Eduard. *Grundriss der Geschichte der Philosophie*. 1st edn 1866. 4th edn 'bearbeitet von Benno Erdmann'. Verlag von Wilhelm Hertz, Berlin. 2 Bände, 1896. Band i, pp.xvi + 682. Band ii, pp.xv + 928.

359 n.1.

FRANCK Adolphe. Article 'Démocrite', in *Dictionnaire des sciences philosophiques* 'par une société de professeurs et de savants, sous la direction de M. Ad. Franck'. 1st edn, 6 tomes, 1844–52 (with separate pagination, except tomes v and vi which are paginated consecutively). 2nd edn in one volume. Librairie Hachette et Cie, Paris. 1875. 1st edn, tome ii (1844) pp.28–36 = 2nd edn, pp.354–8. For the authorship of the article, see the final page of the volume.

248.

FREEMAN Kathleen. *The Pre-Socratic philosophers, a companion to Diels, 'Fragmente der Vorsokratiker'*. Basil Blackwell, Oxford. 1946. Pp.xiii + 486.

289.

FURLEY David John. *Two studies in the Greek Atomists, study I Indivisible magnitudes, study II Aristotle and Epicurus on voluntary action*. Princeton University Press, Princeton, New Jersey. 1967. Pp.viii + 256.

117 n.1. 184 n.1. 270 n.2. 293.

FURLEY David J. 'Aristotle and the Atomists on infinity', *Symposium Aristotelicum* 4 ed. I. Düring (Heidelberg, 1969) 85–96.

221 n.1.

FURLEY David J. 'Aristotle and the Atomists on motion in a void', in *Motion and time, space and matter, interrelations in the history of philosophy and science*, ed. Peter K. Machamer and Robert G. Turnbull. Ohio State University Press. 1976. Pp.83–100.

Furley's contribution, as also that of Hahm, did not reach me in time to be taken account of in the body of my work. Furley introduces a version of Zeller's interpretation, whereby for Democritus 'weight, meaning a tendency to fall vertically, is a primary, irreducible property of the atoms' (p.87). Furley's promise of a fuller study of the evidence for this view (n.20) has, so far as I know, not yet been realised. Furley's preliminary statement of his position does not add significantly to Zeller's analysis of the evidence.

154 n.1. 163 n.1. 347 n.3.

GASSENDI Petrus. *P.G. . . . Animadversiones in decimum librum Diogenis Laertii, qui est de vita, moribus, placitisque Epicuri . . .*. 1st edn 1649. 3rd edn. Lugduni, sumptibus Francisci Barbier, typographi regii. 2 tomi, 1675. Tomus i, Index titulorum + pp.611. Tomus ii, pp.458 + Index rerum ac verborum totius operis.

293 n.1.

GERTH Bernhard, see under KÜHNER Raphael.

GIGON Olog. 'Die π der Vorsokratiker bei Theophrast und Aristoteles', *Symposium Aristotelicum* 4 ed. I. Düring (Heidelberg, 1969) 114–23.

Gigon argues, I think rather implausibly, that Theophrastus' *Physicorum opinionones* is prior to, and was used by Aristotle for, the doxographical discussions at the beginning of the *Physics* and *Metaphysics*.

4 n.1. 281 n.2.

GOEDECKEMEYER Albert. *Epikurs Verhältnis zu Demokrit in der Naturphilosophie*. Karl J. Trübner, Strassburg. 1897. Pp.157.

In a lengthy discussion, 11–27 and 107–24, of the problems of weight and movement in Democritus, Goedeckemeyer is mainly concerned to support Brieger against Zeller, and to demolish the idea of a downward fall of atoms in the void. On the question of weight Goedeckemeyer concludes, 24–5, that 'bei Demokrit eine einheitliche Auffassung der Schwere noch nicht gesucht werden kann'.

133 n.1. 224 n.3. 239 n.1. 269 n.2. 350.

GOMPERZ Theodor. *Griechische Denker, eine Geschichte der antiken Philosophie*. 3 Bände, 1896–1909. There were a number of subsequent editions of the various volumes: Band i finally appeared as 'vierte Auflage, Ausgabe letzter Hand besorgt von H. Gomperz', the son of the author. Vereinigung Wissenschaftlicher Verleger (Walter de Gruyter & Co., *et alii*), Berlin und Leipzig. 1922. Pp.x + 499.

xxi.

GUTHRIE William Keith Chambers. *Aristotle 'On the heavens', with an English translation by W.K.C.G., in the Loeb classical library*. W. Heinemann, London. Harvard University Press, Cambridge, Massachusetts. 1939. Pp.xxxvi + 379.

10 n.3. 81–2. 85 n.1. 98 n.1.

GUTHRIE William Keith Chambers. *A history of Greek philosophy*. University Press, Cambridge. Currently appearing in several volumes. Vol. i, 1962, pp.xv + 359. Vol. ii, 1965, pp.xvii + 554.

My frequent references to Professor Guthrie's *History* may have obscured the fact that the majority of my criticisms are limited to some four or five pages of his text (vol. ii pp.400–4) which contain a brief account of atomist notions of movement and weight. My singling out one part of Professor Guthrie's work in this way will not, I hope, be thought invidious. My intention has been to use Professor Guthrie's *History* as representative of current scholarly opinion, and in so doing to hope to achieve greater clarity and unity in the presentation of my own expression of dissent.

46–7. 62 n.1. Ch.III § 1, 81–100, esp. 94–5. Ch.V § 1, 153–61. 163. 171–2. 177 n.2. 177–9. 181–2. 187 n.4. 203. 203 n.3. *Cf.* 212–13. 245 n.1. 285 n.3. 285 n.4. 287 n.2. 289 n.2. 347–8.

HADOT Ilsetraut. Unpublished paper. See now the following entry.

226 n.1.

HADOT Ilsetraut. *Le problème du Néoplatonisme Alexandri, Héraclès et Simplicius*, in the series *Études Augustiniennes*. Études Augustiniennes, Paris. 1978. Pp.243. Appendice, pp.193–202: 'A propos de l'article de F. Bossier et C. Steel sur le "De anima" attribué à Simplicius'.

HAHM David E. 'Weight and lightness in Aristotle and his predecessors', in *Motion and time, space and matter, interrelations in the history of philosophy and science*, ed. Peter K. Machamer and Robert G. Turnbull. Ohio State University Press. 1976. Pp.56–82.

I regret that this item, as also Furley's contribution to the same volume, did not reach me in time to be considered in the body of my work. Hahm endorses Burnet's interpretation of Democritus, pp.58–9, with the rider that heavy and light require the presence of an observer, as do other of the *sensibilia*. On this latter point *cf.* p.359 n.1 above.

154 n.1. 347 n.3. 359 n.1.

HAMELIN O. 'La pesanteur de l'atome dans le système de Démocrite', *Annales de la faculté des lettres de Bordeaux* (1888) 194–9.

45 n.1. 223 n.1. 359 n.1.

HAMMER-JENSEN Ingeborg. *Den ældste Atomlaehre*, in the series *Studier fra Sprog- og Oldtidsforskning utgivne af det philologisk-historiske Samfund* no. 77. Kjøbenhavn. 1908. Pp.180.

The conclusions of this work are summarised in the following entry.

HAMMER-JENSEN Ingeborg. 'Demokrit und Platon', *Archiv für Geschichte der Philosophie* 23 n.F. 16 (1910) 92–105 and 211–29.

Alfieri, *Atomisti* 2 n.4, writes of this and of the preceding entry that the author, by her analysis of Diog. ix 30–3 (DK 67A1) in conjunction with Plato's *Timaeus* esp. 45B–69A, 'ha dato la vera soluzione al tormentato problema della *Urbewegung*, proseguendo per la strada aperta dal Brieger e dal Liepmann, ma riconoscendo la

funzione del peso in connessione col movimento originario'. This promise does not seem to be realised in Hammer-Jensen's article. Although the author there deals with much of the evidence considered in the present volume, she appears to consider the question of weight solely within the context of a cosmic *dine*. In particular, Hammer-Jensen does not refer to Burnet; her work falls in the limbo, so to speak, between Brieger's 'Urbewegung' (1904) and Burnet's second edition (1908), and her silence on the question of the precosmic atoms is a reminder that for all his other faults Burnet does at least display a certain forthrightness and clarity.

HINDENLANG Ludwig. *Sprachliche Untersuchungen zu Theophrasts botanischen Schriften*, in the series *Dissertationes philologicae Argentoratenses selectae* vol. xiv fasc. 2. K.J. Trübner, Strassburg. 1910. Pp.200.

131 n.1.

HIRZEL Rudolf. *Untersuchungen zu Cicero's philosophischen Schriften*. Verlag von S. Hirzel, Leipzig. 3 Theile, Theil ii im 2 Abtheilungen, 1877–1883. Theil i, pp.244. Theil ii, pp.913. Theil iii, pp.576.

244–5.

INHELDER Bärbel, see under PIAGET Jean.

JARKHO (or YARKHO) V.N. 'On the meaning of epic adjectives with prefix ὀπερ-' [in Russian with an abstract in English], *Journal of ancient history* [in Russian] 117 (1971.3) 78–86.

44 n.1.

JOACHIM Harold H. *Aristotle, 'On coming-to-be and passing-away' (De generatione et corruptione), a revised text with introduction and commentary*. Clarendon Press, Oxford. 1922. Pp.xxxviii + 303.

46 n.3. 59–61. 64.

JOACHIM Harold H. Translation of the *De generatione et corruptione*, in *The works of Aristotle translated into English* ed. W.D. Ross. Clarendon Press, Oxford. Vol. ii, 1930. There is no separate pagination.

43 n.1.

JÜRSS Fritz, MÜLLER Reimar and SCHMIDT Ernst Günther. *Griechische Atomisten. Texte und Kommentare zum materialistischen Denken der Antike, aus dem Griechischen und Lateinischen übersetzt und herausgegeben von F.J., R.M. und E.G.S.*, in the series *Reclams Universal-Bibliothek* Band 409. 1st edn 1973. '2 Auflage'. Verlag Philipp Reclam jun., Leipzig. 1977. Pp.623.

Some rather confused, but ultimately conventional, remarks on the 'weight' of atoms are included in the 'Einleitung', 28–9.

KERCHENSTEINER Jula. 'Zu Leukippos A1', *Hermes* 87 (1959) 441–8.

203 n.3.

KIRK Geoffrey Stephen and RAVEN John Earle. *The Presocratic philosophers, a critical history with a selection of texts*. University Press, Cambridge. 1957. Pp.xi + 487.

The relevant chapter by Kirk contains a couple of pages on weight, 414–16, which reproduce Burnet's interpretation.

xvi. 43–4. 46 n.3. 154 n.1. 172 n.1. 177 n.2. 177 n.4. 287. 293–4. 296–7. 363–4. 380.

KRANZ Walther, see under DIELS Hermann.

KÜHNER Raphael. *Ausführliche Grammatik der griechischen Sprache*. 1st edn 1834. 3rd edn, 2 Teile, jeder Teil im zwei Bänden, 1890–1904. Teil ii Band 2 'in neuer Bearbeitung besorgt von Dr. Bernhard Gerth'. Hahnsche Buchhandlung, Hannover und Leipzig. 1904. Pp.ix + 714.

54 n.2.

LAFAIST Pierre-Benjamin. *Dissertation sur la philosophie atomistique*. L'imprimerie royale, Paris. 1833. Pp.118.

The question of weight occupies most of the section, 68–75, 'Propriétés des atomes': these pages contain a lucid and forceful presentation of the thesis that the atoms were without weight.

210 n.1. 240–1. 338 n.3. 341–3. 359 n.1.

LANGE Friedrich Albert. *Geschichte des Materialismus und Kritik seiner Bedeutung in der Gegenwart*. 1st edn 1866. 2nd edn. Verlag von J. Baedeker, Iserlohn. 2 Bücher, 1873–5. Buch i, pp.xiv + 434. Buch ii, pp.xiii + 573. There were a number of posthumous editions and reprintings.

I include this work, because it is frequently cited in nineteenth century discussions of Democritus, including the question of weight. Lange supposes, 2nd edn i 16–18, that the atoms fall in the void, and catch each other up because of their differences of speed: there is then a passing identification of weight with size, and some brief remarks on weight in Aristotle and Epicurus.

LEWES George Henry. *A biographical history of philosophy*. 1st edn, 4 vols, 1845–6. 5th edn under the title *The history of philosophy from Thales to Comte*. Longmans, Green and Co., London. 2 vols, 1880. Vol. i, pp.cxiv + 410. Vol. ii, pp.x + 773.

350 n.1.

LIARD Louis. *De Democrito philosopho*, followed by the note 'haec apud facultatem litterarum Parisiensem disputabat L.L.'. Versiliis, ex typis Cerf et filii; edebat Parisiis Ladrance bibliopola. 1873. Pp.61.

3 n.1. 350 n.1.

LIEPMANN Hugo Carl. *Die Mechanik der Leucipp-Democritischen Atome, unter besonderer Berücksichtigung der Frage nach dem Ursprung der Bewegung derselben*. This was first published as an *Inaugural-Dissertation zur Erlangung der Doctorwürde der hohen philosophischen Fakultät der Universität Leipzig vorgelegt von H.C.L.* Buchdruckerei von Gustav Schade (Otto Francke), Berlin. 1885. Pp.69. The same text was published in the following year, 1886, with the same title, but without the addition *Inaugural-Dissertation*. . . , and with the same pagination, by Gustav Fock, Leipzig.

Especially noteworthy are pp.31–3, 'Über das Gewicht der Atome, als einzige streitige Eigenschaft derselben'.

13–14. 46 n.3. 136–7. 163. 171–2. 175. 182. 223 n.1. 240 n.2. 262. 269–70. Ch.X § 3, 279–81. Ch.XIII § 1, 347–64, esp. 351–2, 359 n.1.

LONGO Oddone. *Aristotele 'De caelo', introduzione, testo critico, traduzione e note di O.L.*, described as in the series *Classici greci e latini, con testo a fronte, seconda serie, opere di Aristotele, sotto la direzione e con la collaborazione di Carlo Diano*. G.C. Sansoni, Firenze. 1961. Pp.lxxiii + 396.

81 n.2. 85 n.1.

LORTZING F. Review of Brieger, *Urbewegung* 1884, in *Philologischer Anzeiger*, als Ergänzung des *Philologus* herausgegeben von Ernst von Leutsch, Band 15 (1885) 578–83.

118 n.1. 354–6.

LÖWENHEIM. 'Der Einfluss Demokrit's auf Galilei', *Archiv für Geschichte der Philosophie* 7 (1894) 230–68.

LÖWENHEIM Louis. *Die Wissenschaft Demokrits und ihr Einfluss auf die moderne Naturwissenschaft*, herausgegeben von Leopold Löwenheim. Druck und Verlag von Leonhard Simion, Berlin. 1914. Pp.xi + 244. The first 48 pages were also printed, with the same title, as a *Beilage* to *Archiv für Geschichte der Philosophie* 26 n.F. 19 Heft 4 (1913) 1–48.

This was planned as a work in three volumes: there were completed only the present volume, and a sketch of the whole in *AGPh* for 1894, as listed above.

Pp.39–79, entitled 'Die Lehre von der Schwere und von der allgemeinen Anziehung', contain a lengthy and in places a very interesting discussion of

Democritus' conception of weight. Löwenheim concludes that the conflict in the evidence is to be resolved by the Newtonian theory of gravitation, 73:

'Nach meiner Ansicht erklärt sich das Rätsel auf die einfachste Weise: Demokrit dachte sich die Sache genau ebenso wie wir; d.h. er betrachtete die Schwere als einen speziellen Fall der allgemeinen Anziehung. . . . Dieser Ansicht steht die allgemein herrschende Anschauung entgegen, dass vor Newton niemand daran . . . denken konnte, weil erst die Entdeckungen, welche Kepler am Himmel gemacht hat, dergleichen Ansichten nahe zu legen vermochten.'

While it seems to me that Löwenheim confuses conceptual and historical simplicity, he has at least made a genuine attempt to ask himself what expression of weight there can have been, in the light of the evidence that outside a cosmos the atoms do have weight and do not move downwards. Löwenheim's discussion of the evidence is also more careful and more balanced than that which leads to many a supposedly more orthodox interpretation, and he makes no attempt to mask the modern affiliations of the ideas that he attributes to Democritus.

The work (with Löwenheim's earlier article) remains a useful introduction to Galileo's knowledge, and use, of Democritus. It is a great pity that Löwenheim did not live to complete his majestic enterprise.

154 n.1.

LURIA (or LUR'E) Solomon Yakovlevich. *Outlines of the history of ancient science, Greece in her prime* [in Russian], in the collection, *Academy of sciences of the U.S.S.R., popular scientific series* [in Russian]. Press of the Academy of Sciences of the U.S.S.R., Moscow and Leningrad. 1947. Pp.402.

284 n.1.

LUR'E Solomon Yakovlevich, see under LURIA Solomon Yakovlevich.

MABILLEAU Léopold. *Histoire de la philosophie atomistique*. Imprimerie nationale, Félix Alcan éditeur, Paris. 1895. Pp.vii + 560.

'La pesanteur', pp.194–200.

3 n.1. 210 n.1. 248 n.3. 338. 349–50. 361 n.1.

MCDIARMID J.B. 'Phantoms in Democritean terminology: περιπαλάσσειν', *Hermes* 86 (1958) 291–8.

169–71.

MCDIARMID John B. 'Theophrastus *De sensibus* 61–62: Democritus' theory of weight', *Classical philology* 55 (1960) 28–30.

Ch.IV § 1, 116–31.

MARTIN Thomas Henri. *Études sur le Timée de Platon*. Ladrance librairie-éditeur, Paris. 2 tomes, 1841. Tome i, pp.xii + 428. Tome ii, pp.462.

xvii.

MARX Karl Heinrich. *Doktordissertation: Differenz der demokritischen und epikureischen Naturphilosophie nebst einem Anhang*. This comprises: *Erster Teil: Differenz der demokritischen und epikureischen Naturphilosophie im allgemeinen. Zweiter Teil: Über die Differenz der demokritischen und epikureischen Naturphilosophie im einzelnen. [Fragment aus dem Anhang]: Kritik der plutarchischen Polemik gegen Epikurs Theologie*. Written 1840–March 1841; printed in *Karl Marx, Friedrich Engels: Werke . . . Ergänzungsband Teil i*. Dietz Verlag, Berlin. 1968. Pp.257–373.

The second chapter of the *Zweiter Teil*, 'Die Qualitäten des Atoms', pp.285–90, contains a not uninteresting account, whereby for Democritus weight is not a primary character of the atoms because 'wir . . . bei Demokrit blosse hypothetische Bestimmungen zur Erklärung der Erscheinungswelt finden' (p.287), whereas for Epicurus, 'die Atome sind selbst *substantiale Schwerpunkte* wie die Himmelskörper' (p.289).

MAZZIOTTI Manlio, see under ENRIQUES Federigo.

MORAUX Paul. 'Einige Bemerkungen über den Aufbau von Aristoteles' Schrift *De caelo*', *Museum helveticum* 6 (1949) 157–65.

There is a later version of this article in the *Revue thomiste* for 1951: the substance of both articles is incorporated into the introduction to Moraux's Budé edition.

MORAUX Paul. 'Recherches sur le *De caelo* d'Aristote, objet et structure de l'ouvrage', *Revue thomiste* année 59 tome 51 (1951) 170–96.

The substance of this article is resumed, with some corrections, in the introduction to Moraux's Budé edition.

10–11.

MORAUX Paul. *Aristote 'Du ciel', texte établi et traduit par P.M.*, in the series *Collection des Universités de France*, publiée sous le patronage de l'Association Guillaume Budé. Société d'édition 'Les Belles Lettres', Paris. 1965/6. Pp.cxc + 165 (pp.1–154 double).

Pp.cxliv–clvii, 'La pesanteur et la légèreté', contain an analysis of book four.

10 n.3. 42 n.2. 64 n.1. 81 n.2. 85 n.1. 112 n.1. 284–6.

MOUY Paul. *Le développement de la physique cartésienne 1646–1712*, in the series *Bibliothèque d'histoire de la philosophie*. Librairie philosophique J. Vrin, Paris. 1934. Pp.x + 343.

349 n.2.

MUGLER Charles. 'Sur quelques particularités de l'atomisme ancien', *Revue de philologie* série 3, année et tome 27 (1953) 141–74.

284–7. 288 n.3.

MUGLER Charles. 'L'isonomie des Atomistes', *Revue de philologie* série 3, année et tome 30 (1956) 231–50.

284–7.

MUGLER Charles. 'Platonica', *L'antiquité classique* 25 (1956) 20–31.

290 n.2.

MUGLER Ch. 'Les théories de la vie et de la conscience chez Démocrite', *Revue de philologie* série 3, année et tome 33 (1959) 7–38.

284–7. 289 n.2.

MUGLER Ch. 'L'invisibilité des atomes, à propos d'un passage d'Aristote (*De gen. et corr.* 325a30)', *Revue des études grecques* 76 (1963) 397–403.

284–7.

MUGLER Charles. *Aristote 'De la génération et de la corruption', texte établi et traduit par C.M.*, in the series *Collection des Universités de France*, publiée sous le patronage de l'Association Guillaume Budé. Société d'édition 'Les Belles Lettres', Paris. 1966 (printed 1965). Pp.xviii + 101 (pp.1–74 double).

46 n.3. 64. 286–7. 298 n.1.

MULLACH Friedrich Wilhelm August. *Democriti Abderitae operum fragmenta collegit, recensuit, vertit, explicuit, ac de philosophi vita, scriptis et placitis commentatus est F.G.A.M. Berolini, sumptibus Guil. Besseri.* 1843. Pp.xvi + 438.

Pp.214–15 and 346–8 contain text, translation and notes for Theophrastus *De sensibus* 61–2.

46 n.3. Ch.IV § 1, 116–31. 172 n.1. Ch.X § 3, 279–81.

MULLACH Friedrich Wilhelm August. *Fragmenta philosophorum graecorum collegit recensuit vertit annotationibus et prolegomenis illustravit indicibus instruxit F.G.A.M.* Parisiis, Didot. 3 vols, 1860–81. Vol. i *Poeseos philosophicae caeterorumque ante Socratem philosophorum quae supersunt*. Pp.xxvii + 575.

Democritus, i 330–82: p.361 reproduces the text and translation of Theophrastus *De sensibus* 61–2, taken from Mullach's earlier monograph.

MÜLLER Reimar, see under JÜRSS Fritz.

NESTLE Wilhelm, see under ZELLER Eduard.

O'BRIEN D. 'The relation of Anaxagoras and Empedocles', *Journal of hellenic studies* 88 (1968) 93–113.

378 n.3.

O'BRIEN D. 'Derived light and eclipses in the fifth century'. *Journal of hellenic studies* 88 (1968) 114–27.

298 n.1.

O'BRIEN Denis. *Empedocles' cosmic cycle, a reconstruction from the fragments and secondary sources*, in the series *Cambridge classical studies*. University Press, Cambridge. 1969. Pp.x + 459.

311. 312 n.1. 336. 368. 370 n.1. 378 n.2. See also BOLLACK (1969) in the Bibliography.

O'BRIEN D. 'The earliest theories of weight: "heavy" and "light" in Democritus, Plato and Aristotle', *The classical bulletin* 52 (1976) 49–50.

A note announcing the present study. (Correct line 16 to read 'atoms that are inside a cosmos'.)

O'BRIEN D. 'Heavy and light in Democritus and Aristotle: two conceptions of change and identity', *Journal of hellenic studies* 97 (1977) 64–74.

An introductory outline to all four volumes of the present work.

O'BRIEN D. 'L'atomisme ancien: la pesanteur et le mouvement des atomes chez Démocrite', *Revue philosophique de la France et de l'Etranger* année 104 tome 169 (1979) 401–26.

An introduction to vol. i of the present work.

O'BRIEN D. 'Aristote: quantité et contrariété; une critique de l'école d'Oxford', in *Concepts et catégories dans la pensée antique*, 'études publiées sous la direction de Pierre Aubenque', in the series *Bibliothèque d'histoire de la philosophie*. J. Vrin, Paris. 1981. Pp.89–165.

50 n.2.

O'BRIEN Denis. *Théories présocratiques de la perception et de l'intelligence, étudiées d'après la tradition biographique d'Empédocle*, forthcoming in the series *Philosophia Antiqua*.

254. 342.

PAPENCORDT Felix. *De atomicorum doctrina commentationis specimen primum, Dissertatio inauguralis philosophica philologica quam . . . in Universitate literaria Friderica Guilelma . . . publice defensurus est scriptor F.P. Berolini*, typis Nietackianis. 1832. Pp.72.

Theophrastus *De sensibus* 61, pp.53–4.

Ch.IV § 1, 116–31. 172 n.1. 279 n.3.

PARENTE Margherita Isnardi. *Opere di Epicuro, a cura di M.I.P.*, in the series *Classici della filosofia, collezione diretta da Nicola Abbagnano*. Unione tipografico-editrice Torinese, Torino. 1974. Pp.629.

326 n.1.

PHILIPPSON Ludwig. "Υλη ἀνθρωπίνη. *Pars i: De internarum humani corporis partium cognitione Aristotelis cum Platonis sententiis comparata. Pars ii: Philosophorum veterum usque ad Theophrastum doctrina de sensu* [with three subtitles of which the first is] *Theophrasti de sensu et sensibus fragmentum historico-philosophicum, cum textu denuo recognito prima conversio latina et commentaria . . . scripsit et edidit L.P. Berolini*, sumtibus J.A. List. 1831. Pp.vii + 252.

Introduction, text, translation and commentary for Theophrastus *De sensibus*, pp.81–229.

Ch.IV § 1, 116–31.

PIAGET Jean and INHELDER Bärbel. *Le développement des quantités chez l'enfant, conserva-*

tion et atomisme, under the superscription *Collection d'actualités pédagogiques*. Delachaux et Niestlé, Neuchâtel et Paris. 1941. Pp.iii + 344.

PICCOLOMINEUS Franciscus. *F.P. Senensis. Commentarii in libros Aristotelis De coelo, ortu et interitu; adiuncta lucidissima expositione, in tres libros de anima, nunc recens in lucem prodeunt*. Moguntiae, excudebat Ioannes Albinus, impensis Conradi Meullii civis Francofurtani. 1608. Pp.360 + 1019.

226 n.1.

PILLON F. 'L'évolution historique de l'atomisme', *L'année philosophique*, publiée sous la direction de F. Pillon, 2 (1891) 67–208.

224 n.3. 239 n.1. 240 n.2. 349–50. 361 n.1. See also BOLLACK (1969) in the Bibliography.

RAVAISSON Félix. *Essai sur la métaphysique d'Aristote*. Paris. 2 tomes, 1837–46. Tome i, L'imprimerie royale, pp.vii + 599. Tome ii, Librairie de Joubert éditeur, pp.vi + 584.

350 n.1.

RAVEN John Earle, see under KIRK Geoffrey Stephen.

REGENBOGEN O. Article on 'Theophrastos', in Pauly-Wissowa's *Real-Encyclopädie der classischen Altertumswissenschaft* Supplementband vii (1940) coll.1354–1562.

301 n.1.

REGNELL Hans. *Ancient views on the nature of life, three studies in the philosophies of the Atomists, Plato and Aristotle*, in the series *Library of theoria* no. 10. CWK Gleerup, Lund. 1967. Pp.267.

154 n.1.

REINHARDT Karl. *Parmenides und die Geschichte der griechischen Philosophie*. Verlag von Friedrich Cohen, Bonn. 1916. Pp.263.

301 n.1.

RENOUVIER Charles. *Manuel de philosophie ancienne*. Paulin librairie-éditeur, Paris. 2 vols, 1844. Vol. i, pp.li + 324. Vol. ii, pp.405.

Democritus on weight, i 245–6.

45. 348–50. 359 n.1.

RIVAUD Albert. *Le problème du devenir et la notion de la matière dans la philosophie grecque depuis les origines jusqu'à Théophraste*. Félix Alcan éditeur, Paris. 1906. Pp.488.

Pp.160–75 'Le poids des atomes' contain a detailed and on the whole a judicious account of the evidence, and of previous interpretations of it. In the first pages of this section, 160–4, Rivaud concludes that the atoms do have weight. He then asks himself, very properly, 164–5:

'Mais, si les atomes sont pesants quelle idée Leucippe et Démocrite se faisaient-ils de la pesanteur? La pesanteur est-elle la cause du mouvement des atomes?'

In the pages which remain, 165–75, Rivaud fairly clearly answers the second question negatively. But from his very detailed discussion I cannot discover whether Rivaud thought that there was any alternative expression for the weight of atoms, and if so what it may have been. It is, I think, for this reason that apart from a passing reference in Robin ('L'atomisme ancien' 211 n.1 = *Pensée hellénique* 74 n.1), Rivaud's work seems to have remained without influence on subsequent scholars.

88 n.1. 133 n.1. 154 n.1. 239 n.1. 269 n.2.

ROBIN Léon. *La pensée grecque et les origines de l'esprit scientifique*, in the series *L'évolution de l'humanité, bibliothèque de synthèse historique*. La Renaissance du Livre, Paris. 1923. Pp.xii + 480. [Reprinted] Éditions Albin Michel, Paris. 1948. Pp.xxi + 504. The pagination up to but excluding the bibliography (pp.457ff.) is unchanged in this reprinting and in:

'nouvelle édition avec une bibliographie complémentaire par Pierre-Maxime Schul', in the same series. Éditions A. Michel, Paris. 1963. Pp.xxi + 517.

154. n.1. 287 n.3. 340–1.

ROBIN Léon. 'L'atomisme ancien', *Revue de synthèse, organe du centre international de synthèse, fondation 'Pour la science'* 6 (1933) 205–16.

Reprinted in *La pensée hellénique* 67–80.

42 n.2. 154 n.1. 171 n.1. 340–3. See also RIVAUD (1906) in the Bibliography.

ROBIN Léon. *La pensée hellénique des origines à Épicure, questions de méthode, de critique et d'histoire*, in the series *Bibliothèque de philosophie contemporaine*. Presses Universitaires de France, Paris. 1942. Pp.554. The pagination is unchanged in the 2nd edn, Presses Universitaires de France, Paris, 1967.

This is a collection of some of Robin's earlier articles, including 'L'atomisme ancien' (1933), pp.67–80.

Ross William David. *Aristotle's 'Physics', a revised text with introduction and commentary*. Clarendon Press, Oxford. 1936, a corrected reprint 1955. Pp.xii + 750.

187 n.4. 378 n.3.

SAMBURSKY Samuel. *The physical world of the Greeks*, translated from the Hebrew of the 1st edn (1954) by Merton Dagut. Routledge and Kegan Paul, London. 1956. Pp.x + 255.

121 n.1. 255 n.2. 287 n.3. 295–7.

SAMBURSKY S. 'A Democritean metaphor in Plato's *Kratylos*', *Phronesis* 4 (1959) 1–4.

167–8.

SCHMIDT Ernst Günther, see under JÜRSS Fritz.

SCHNEIDER Ioannes Gottlob. *Theophrasti Eresii quae supersunt opera et excerpta librorum quatuor* [eventually five] *tomis comprehensa ad fidem librorum editorum et scriptorum emendavit historiam et libros VI de causis plantarum coniuncta opera D.H.F. Linkii excerpta solus explicare conatus est I.G.S. Sumtibus F.C.G. Vogelii, Lipsiae. 1818–21. Vol.i, pp.xl + 896. Vol. ii, pp.vi + 630. Vol. iii, pp.843. Vol. iv, pp.873. Vol. v, pp.lxvi + 549.*

The text of the *De sensibus* is contained in vol. i 647–85. Notes, commentary and apparatus are then scattered throughout ii 616–25, iv 515–34 and v lii–lv and 141–6, cf. 233.

Ch.IV § 1, 116–31.

SCHWAB Otto. *Historische Syntax der griechischen Comparison in der klassischen Litteratur*, Band iv of *Beiträge zur historischen Syntax der griechischen Sprache*, herausgegeben von M. Schanz. A. Stuber's Verlagsbuchhandlung, Würzburg. 3 Hefte, 1893–5. Pp.viii × 523 (also paginated separately for each *Heft*.)

98 n.1.

SOLMSSEN Friedrich Rudolph Heinrich. *Aristotle's system of the physical world, a comparison with his predecessors*, in the series *Cornell studies in classical philology* vol. 33. Cornell University Press, Ithaca, New York. 1960. Pp.xiv + 468.

Chapter 13 'Heavy and light', pp.275–86.

xviii. 154 n.1. 176 n.1. 177 n.2.

STEEL C., see under BOSSIER F.

STEINMETZ Peter. *Die Physik des Theophrastos von Eresos*, in the series *Palingenesia. Monographien und Texte zur klassischen Altertumswissenschaft* ed. Rudolf Stark Band i. Verlag Dr Max Gehlen, Bad Homburg V.D.H., Berlin, Zürich. 1964. Pp.376.

Especially relevant to this study is the *Beilage*, 'Theophrasts Physik und ihr Verhältnis zu den φυσικῶν δόξαι' (pp.334–51).

4 n.1. 281 n.2. 301 n.1.

STEPHANUS Henricus. *Aristotelis et Theophrasti scripta quaedam, quae vel numquam antea, vel minus emendata quam nunc, edita fuerunt*. Ex officina Henrici Stephani Parisiensis typographi. 1557. Pp.168.

This includes the *editio princeps* of Theophrastus *De sensibus*, pp. 17–46.

116.

STOCKS John Leofric. Translation of the *De caelo*, in *The works of Aristotle translated into English* ed. W.D. Ross. Clarendon Press, Oxford. Vol. ii, 1930. There is no separate pagination.

81 n.2. 85 n.1.

STRATTON George Malcolm. *Theophrastus and the Greek physiological psychology before Aristotle*. George Allen and Unwin, London. MacMillan and Company, New York. 1917. Pp.227.

This contains Diels' text, with a translation, and notes which are largely derived from correspondence with A.E. Taylor.

xvi–xviii. Ch.IV § 1, 116–31, esp. 121 n.1. 149. 255 n.2. 371 n.1.

STROHMAIER Gotthard. 'Demokrit über die Sonnenstäubchen, ein neues Fragment in arabischer Überlieferung', *Philologus* 112 (1968) 1–19.

177 n.4. 287 n.3.

SWEENEY Leo. *Infinity in the Presocratics: a bibliographical and philosophical study*. Martinus Nijhoff, The Hague. 1972. Pp.xxxiii + 222.

214 n.1.

TANNERY Paul. *Pour l'histoire de la science hellène, de Thalès à Empédocle*. 1st edn, 1887. 2nd edn by A. Diès. Gauthier-Villars et Cie, Paris. 1930. Pp.xxiv + 435.

'Appendice I', pp.348–80, contains a translation of Theophrastus *De sensibus*.

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The editions specified are intended primarily as justification of the texts I have transcribed, although where it does not significantly alter the sense I have felt free to change punctuation and accentuation, and on occasion to adopt a reading from the *apparatus*, without further acknowledgement of the fact. Longer discussions are preceded by a reference to chapter and section.

The English versions of Greek texts are my own. Except when they are specifically introduced as translations, they have been deliberately cast in the form of an expanded translation or paraphrase. This is intended as an economical way of making my interpretation of minor points immediately clear; it means however that these versions must be read as a commentary upon the text, and cannot be used as a substitute for it.

<i>BT</i>	<i>Bibliotheca Scriptorum Graecorum et Romanorum Teubneriana.</i>
Budé	<i>Collection des Universités de France</i> , publiée sous le patronage de l'Association Guillaume Budé.
<i>CAG</i>	<i>Commentaria in Aristotelem Graeca</i> , edita consilio et auctoritate Academiae Litterarum Regiae Borussicae.
<i>GCS</i>	<i>Die Griechischen Christlichen Schriftsteller der ersten drei Jahrhunderte.</i>
<i>LCL</i>	<i>Loeb Classical Library.</i>
<i>OCT</i>	<i>Scriptorum Classicorum Bibliotheca Oxoniensis</i> (Oxford Classical Texts).
<i>PG</i>	Migne's <i>Patrologiae Cursus Completus, series graeca.</i>

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iv 1, 308a31-3 8 n.2. 14 n.1.

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RÉSUMÉ EN FRANÇAIS

Introduction

Théories de la Pesanteur dans l'Antiquité

Comment se dégager des présupposés d'une pensée anachronique, en interrogeant les textes de l'Antiquité? Ce problème est crucial pour qui veut étudier les théories de la pesanteur exposées dans le *Timée* de Platon et dans le traité *Du ciel* d'Aristote: l'une et l'autre théorie font de nos jours l'objet d'analyses où l'on voit transparaître l'influence d'idées postérieures, étrangères à la pensée de l'Académie et du Lycée.

Le problème devient encore plus complexe si nous essayons d'atteindre la théorie à laquelle s'opposèrent Aristote et Platon. Les écrits de Démocrite, nombreux, avaient très tôt disparu; bien des historiens de l'Antiquité n'en ont connu la doctrine qu'à travers des idées forgées par Aristote pour la renverser. Ainsi en est-on venu—confondant la cible et le tireur—à rapprocher la théorie de Démocrite de celle de son adversaire.

Les historiens modernes renchérissent sur cette erreur. Ils sont eux aussi tributaires d'Aristote, et partagent sur plus d'un point sa mentalité: il en résulte que les documents imprégnés d'idées péripatéticiennes retiennent seuls, ou par privilège, leur attention, si bien qu'aujourd'hui encore on interprète Démocrite à travers les idées d'Aristote, tout comme on interprète Aristote à travers les idées des penseurs du Moyen-Age et de la Renaissance.

Pour porter remède à ces inconséquences, il faudra mettre à nu tout autant les présupposés propres à Aristote que les présupposés qui lui sont étrangers: ceux-ci altèrent notre exégèse de la pensée d'Aristote; ceux-là obscurcissent notre intelligence de la théorie qu'il a voulu renverser.

Première partie: témoignages directs

Chapitre I—

Critique générale par Aristote de la théorie atomiste

Commençons par Aristote, et par ses critiques contre les Atomistes dans le traité *Du ciel*. On a pensé qu'Aristote refusait à ses prédécesseurs, et plus particulièrement aux Atomistes, le concept d'une pesanteur absolue, si bien qu'il n'aurait reconnu aux atomes qu'une pesanteur relative, voire «irréelle». Mais si, pour Aristote, les Atomistes appartiennent en effet à cette majorité qui ignore la notion d'une pesanteur absolue, ils appartiennent aussi à une minorité, qui reconnaît du moins l'une des «espèces» de la pesanteur, non point la «légèreté absolue», mais la «lourdeur absolue».

Ce paradoxe s'explique par la distinction des atomes et des corps composés. L'air et la terre sont composés d'atomes; une quantité d'air tombera donc plus vite si elle est faite d'atomes plus gros ou plus nombreux que ceux d'une certaine quantité de terre. Deux conclusions pourraient alors s'imposer. L'air étant plus lourd que la terre, celle-ci ne serait pas, pour Démocrite, d'une lourdeur absolue, comme elle l'est pour Aristote. Mais les atomes qui constituent ces deux éléments n'en sont pas moins d'une lourdeur absolue, dans l'exacte mesure où plus nombreux ils tombent toujours plus vite.

Chapitre II—

Le «De generatione et corruptione» d'Aristote

La notion de pesanteur absolue est essentielle à la critique exposée dans le *De generatione et corruptione*. Aristote s'élève dans ce texte contre l'«impassibilité» des atomes, en faisant appel à une différence de pesanteur: si un atome est plus lourd qu'un autre, il devrait y avoir un atome plus chaud qu'un autre; mais l'atome qui l'emporterait en chaleur ne pourrait pas alors ne pas affecter l'atome moins chaud que lui. Les atomes doivent donc «pâtir», les uns sous l'effet des autres.

Cette critique repose sur l'«inactivité» de la pesanteur dans la conception du Stagirite: si le feu réchauffe quand on s'en approche, en revanche la pierre qui écrase ne rend pas plus lourd; en ces sens, elle est «inactive». C'est donc la chaleur et non la pesanteur qui met en évidence «l'activité» des atomes.

Mais la notion de pesanteur est tout aussi essentielle à l'argument. La «lourdeur absolue» suppose que les atomes sont plus ou moins lourds les uns que les autres, sans d'ailleurs que l'atome «moins lourd» soit de ce fait «plus léger». La théorie atomiste de la température est sur ce point analogue: Démocrite rattache la chaleur à la rondeur des atomes, mais il n'en saurait expliquer la «froideur», puisque la rondeur n'admet pas de contraire. Aristote tire parti de ce parallélisme: l'absence d'un second terme dans les deux oppositions («froid»/«léger») lui permet de rapprocher la chaleur de la lourdeur des atomes.

On saisit dès lors le nerf de cette argumentation: la différence de lourdeur suppose une différence de chaleur; la différence de chaleur rend les atomes actifs et «passibles» (sujets à pâtir).

Chapitre III—

Le «De caelo» d'Aristote

En quoi consiste la pesanteur? Aristote laisse entrevoir sa pensée à ce sujet dans un texte du *De caelo*, où il oppose la théorie de Platon à celle des Atomistes. Platon ne peut expliquer comment le corps le plus gros est parfois le plus léger: les triangles étant tous d'une seule et même espèce, une augmentation de volume dans les corps qu'ils constituent devrait nécessairement s'accompagner d'une augmentation de poids. Le corps le plus gros serait donc toujours le plus pesant. Les Atomistes, au contraire, peuvent augmenter le volume d'un corps, en le gonflant de vide, sans accroître son poids. Le corps le plus gros devient alors parfois le plus léger.

Ce contraste en appelle un autre. On tombe dans l'absurde, quand on cherche à construire des corps matériels, en utilisant des surfaces. En revanche, les Atomistes, qui considèrent les corps indivisibles comme des solides, auraient droit de dire que le plus gros d'entre eux est aussi le plus pesant.

On a confondu ces deux critiques, en interprétant la formule «le plus gros. . . le plus pesant.» comme visant uniquement les corps composés. Il est au contraire évident que, si cette formule s'applique, dans la première critique d'Aristote, aux corps composés de Platon, elle ne s'applique, dans la seconde, qu'aux atomes. De la du vide dans les corps composés, il s'ensuit, pour les Atomistes, que le corps composé présence le plus gros est aussi parfois le plus léger (première critique); en revanche, ce sont les atomes qui, plus gros, sont plus pesants (seconde critique).

On devine, certes, dans ce texte, l'accentuation de détails qui atteste les soucis d'Aristote plutôt que ceux de Démocrite. Par exemple, Aristote observe, dans la suite de sa critique, qu'en fondant la légèreté des corps composés sur la part de vide qui est en eux, les Atomistes ont négligé de préciser la part de solide. Mais la

proportion de vide suffit en effet pour établir une comparaison entre des corps de volume égal. En négligeant la part de solide, les Atomistes ne cherchaient probablement pas à comparer des corps de volumes inégaux; c'est Aristote qui a infléchi en ce sens la théorie primitive, pour mieux l'adapter à sa critique de Platon.

Que conclure? Malgré les risques d'anachronisme imputable à la polémique d'Aristote, il nous semble, après avoir rapproché le *De generatione et corruptione* et le *De caelo*, que, selon Démocrite, la différence de pesanteur va de pair avec une différence de grandeur.

Chapitre IV— Theophraste

La même théorie se fait jour dans le traité *Sur la faculté de sentir et sur les objets des sens* de Théophraste: la pesanteur des atomes est définie par la grandeur, toute différence de forme mise à part; dans les corps composés, le corps le plus léger sera celui qui aura davantage de vide.

On a mal compris ce texte, en confondant taille et figure. Théophraste en effet ne parle pas d'atomes dont la figure serait la même; c'est la taille des atomes qui en détermine la pesanteur, si bien que, même s'ils diffèrent par la figure, deux atomes de même taille sont aussi du même poids.

Plus complexe est la partie critique du traité. Pour Théophraste, comme pour Aristote, la pesanteur se traduit par une diversité de mouvements et de natures dans les corps cosmiques (l'air, l'eau, le feu, la terre). En définissant la pesanteur par la seule grandeur des atomes, Démocrite aurait imposé aux atomes cosmiques un même mouvement, donc une seule et même nature.

«Mouvement» et «nature» se retrouvent dans un texte d'Aristote, à cette différence près que, pour ce dernier, les atomes auraient une seule nature, donc un seul et même mouvement. Ce renversement des termes de la critique repose sur deux concepts différents de «nature». La «nature» dont parle Aristote est celle même des Atomistes: c'est l'homogénéité de la substance atomique. Mais Aristote déduit de cette identité de nature une identité de mouvement. Cette conclusion d'Aristote sert de point de départ à la critique de Théophraste: un même mouvement traduit une même nature; une même «nature», au sens aristotélicien du terme, contredit de façon flagrante la diversité qu'Aristote et Théophraste prêtaient aux corps cosmiques.

Cette critique influera profondément sur la tradition doxographique ultérieure. Mais à s'en tenir aux seuls témoignages directs dont nous disposons, celui de Théophraste après celui d'Aristote, la conclusion de notre chapitre III s'avère et se précise: les atomes sont dotés d'une pesanteur, laquelle est proportionnelle à leur taille.

Deuxième partie: témoignages indirects

Chapitre V— Simplicius

La grande majorité des exégètes repoussent la conclusion de la tradition directe. Dans la tradition indirecte, notamment chez Aétius, les atomes seraient privés de pesanteur. Pour concilier les deux témoignages d'Aétius et d'Aristote, on a proposé de voir dans la pesanteur un des produits du tourbillon cosmique: ainsi les atomes ne seraient pesants qu'au sein d'une cosmogonie; les atomes non-cosmiques, eux, ne sont pas pesants.

||Pour conforter cette hypothèse, on invoque Simplicius, lequel affirmerait, dans son commentaire du *De caelo*, que la pesanteur est une simple apparence,

n'intervenant par conséquent que dans un monde structuré. Mais cette interprétation résulte d'une méprise. Simplicius est en fait solidaire d'Aristote: pour tous les deux, ce n'est pas la lourdeur, mais la légèreté qui est une apparence dans le système atomiste. Simplicius explique en effet comment le tourbillon, qui imprime à des atomes un mouvement vers le haut, fait «apparaître» la légèreté. Mais il ne considère pas comme adventice la lourdeur, dans la mesure où il l'attache à la solidité et à l'homogénéité des atomes.

Le commentaire de la *Physique* est encore plus explicite. En parlant, semble-t-il, des atomes qui ne sont pas dans un cosmos, Simplicius affirme qu'ils «se meuvent selon la pesanteur qui est en eux». Impossible de concilier ce témoignage avec l'hypothèse d'une absence de pesanteur dans les atomes non-cosmiques.

Chapitre VI— Simplicius et l'opinion reçue

Le texte du commentaire de la *Physique* met en cause le rapport de la pesanteur et du mouvement. Aristote laisse pressentir dans plusieurs passages que les atomes se dirigent en tous sens dans le vide. D'où la difficulté de savoir comment, pour Simplicius, les atomes «se meuvent selon la pesanteur qui est en eux»: la pesanteur n'est-elle pas censée se traduire par un mouvement en un seul sens, de haut en bas?

Cette question fondamentale a provoqué jusqu'ici deux réponses diamétralement opposées. Pour les uns, notamment pour Zeller, on devrait adopter le témoignage d'Aristote sur la pesanteur, mais rejeter son témoignage sur le mouvement. Dans le système de Démocrite, comme dans celui d'Épicure, la pesanteur imprimerait donc aux atomes un mouvement de haut en bas dans le vide. Les autres, à la suite de Burnet, ont envisagé l'hypothèse contraire: les atomes ne tombent pas dans le vide; ils seraient par conséquent privés de pesanteur, comme l'affirme d'ailleurs Aëtius.

Ce conflit ne peut se résoudre que si l'on se libère du préjugé qui fait de la pesanteur une cause de mouvement en un sens déterminé. Lisons en ce sens le commentaire de Simplicius sur la *Physique*. Celui-ci parle d'un «éclaboussement» des atomes, tout en donnant leur mouvement comme «conforme à la pesanteur». De toute évidence, dans l'optique de Simplicius, le mouvement en un sens unique n'accompagne pas nécessairement chez Démocrite la pesanteur. Celle-ci, si l'on invoque d'autres textes, apparaît liée à des phénomènes de choc ou de vitesse dans le mouvement des atomes.

Simplicius renchérit donc sur le témoignage d'Aristote et de Théophraste: la pesanteur est une propriété innée des atomes; le mouvement des atomes non-cosmiques lui est en quelque sorte conforme, sans pour autant qu'elle leur imprime un mouvement de haut en bas.

Chapitre VII— Diogène Laërce et Alexandre d'Aphrodise

Examinons d'autres témoins de la tradition indirecte. Diogène Laërce parle de l'«équilibre» des atomes, mais c'est à tort qu'on a cru voir dans cette expression une allusion à l'absence de pesanteur dans les atomes non-cosmiques. Diogène évoque la formation d'un monde, dans lequel les atomes seraient aspirés par un tourbillon; les atomes resteraient «en suspension», avant de se répartir entre le centre et la périphérie du monde.

Plus parlant est un texte du commentaire de la *Métaphysique*, où Alexandre

d'Aphrodise s'interroge sur les «parties» des atomes, en faisant appel à un passage «du troisième livre du *De caelo*»: comment pourrait-on imaginer qu'un corps doué de pesanteur soit construit de parties qui en seraient privées? Ce texte superpose anachroniquement deux méprises. À en croire Simplicius, ce n'est pas Démocrite, mais Épicure qui postula le premier des «parties conceptuelles», pour esquiver les critiques élaborées par Aristote contre l'indivisibilité des atomes. Par ailleurs, ce n'est pas Démocrite, mais bien Platon qui est visé dans le texte du *De caelo* cité par Alexandre.

En commentant ce texte, Alexandre met en parallèle les triangles de Platon et les atomes de Démocrite. Ce rapprochement explique l'erreur qu'on trouve dans le commentaire de la *Métaphysique*: le grief qu'Aristote faisait à Platon, dans le *De caelo*, d'avoir fondé la pesanteur sur des éléments qui en seraient privés, Alexandre le reporte sur la théorie de Démocrite, contre les «parties» des atomes.

Cette erreur première n'a-t-elle pas engendré une seconde erreur? Dans le même commentaire de la *Métaphysique*, Alexandre met sur un pied d'égalité pesanteur et mouvement: quelle serait l'origine du mouvement, si les atomes n'ont pas de mouvement «naturel»? Quelle serait l'origine de la pesanteur, si les «parties» des atomes en sont privées? Ce parallélisme suggère que, dans l'esprit du commentateur, la pesanteur était cause et seule cause de mouvement naturel; par implication réciproque, absence de mouvement naturel signifiait nécessairement pour lui absence de pesanteur dans les «parties» des atomes.

Chapitre VIII— Aétius et Cicéron

Retrouve-t-on le même enchaînement de concepts chez l'auteur qui mit la dernière main à la *Collection d'opinions physiques* (le *Physicorum opiniones*), dont les origines remontent à Théophraste? Pour Aétius, les atomes n'auraient pas de pesanteur, leur mouvement se produirait en vertu de leur «choc mutuel». Cette expression rappelle l'opposition du mouvement «violent» et du mouvement «naturel» dans le système d'Aristote. L'absence de pesanteur ne serait-elle donc, pour Aétius comme pour Alexandre, qu'un simple corollaire de ce «choc mutuel», de cette absence de mouvement naturel?

Le concept de mouvement violent a très probablement déteint sur la notice précédente de la *Collection*, où l'auteur énumère les mouvements successifs des atomes dans le système d'Épicure: la chute, la déclinaison, enfin le choc et le rebondissement. Pour Épicure lui-même, ce choc et ce rebondissement impriment aux atomes un mouvement latéral et un mouvement vers le haut. Aétius ne fait allusion qu'au mouvement vers le haut. Son silence trahit l'influence du Lycée: pour Épicure comme pour Aristote, le mouvement latéral est un mouvement violent; en revanche, il appartient en propre au seul système d'Épicure de déterminer comme «violent» tout mouvement vers le haut.

Une notice antérieure de la même *Collection* présente la pesanteur comme une innovation d'Épicure, les atomes de Démocrite ne se distinguant les uns des autres que par une différence de taille et de figure. L'auteur peut vouloir dire, ici comme dans la notice postérieure, qu'Épicure fut le premier à parler d'une pesanteur des atomes. Mais si l'on se souvient qu'en toute hypothèse la pesanteur n'a pas chez Démocrite l'importance qu'elle aura chez Épicure, une seconde interprétation est possible: Épicure a innové en valorisant la pesanteur, pour répondre aux critiques d'Aristote sur l'origine du mouvement.

Un témoignage de Cicéron n'est guère plus clair. Il oppose le «choc» des atomes dans le système de Démocrite à leur pesanteur dans le système d'Épicure, sans toutefois nier la pesanteur des atomes chez le premier.

On a examiné les témoignages marquants de la tradition indirecte. Contrairement à ce qu'a supposé la majorité des exégètes modernes, les auteurs ne sont pas unanimes. Aétius refuse une pesanteur aux atomes. Simplicius la leur concède à plusieurs reprises, notamment dans sa description des atomes non-cosmiques.

Troisième partie: conciliation des témoignages

Chapitre IX—

Valeur des témoignages de tradition directe

Comment mesurer la valeur relative de ces divers témoignages? L'avis d'Aétius l'emporte-t-il sur le témoignage contraire de Simplicius? Peut-il modifier le témoignage de tradition directe, celui d'Aristote et de Théophraste?

Aristote, il est vrai, infléchit souvent les théories de ses prédécesseurs. Théophraste de même, bien qu'il sépare en principe exégèse et critique, en vient parfois à les confondre. Doit-on en inférer que ces deux auteurs ont pu négliger de préciser que les atomes ne sont doués de pesanteur qu'à l'intérieur d'un cosmos? En fait, les textes cités ne laissent voir aucune trace de cette négligence; plus d'un indice au contraire semble la démentir.

Chapitre X—

Valeur des témoignages de tradition indirecte

Simplicius a subi de sévères critiques de la part des historiens modernes. On le taxe notamment d'inconséquence: les atomes qui auraient des «parties» selon le commentaire de la *Physique*, ne les auraient pas selon le commentaire du *De caelo*. Mais ce n'est que méconnaître les subtilités de la pensée de Simplicius. Pour lui comme pour Aristote, tout ce qui est étendu est, par là même, divisible. Si donc les atomes sont considérés comme étendus, c'est qu'ils doivent avoir aussi des «parties». En revanche, si les atomes n'ont pas de «parties», c'est qu'ils ne sont pas étendus et ne peuvent pas constituer les corps matériels du monde sensible. Simplicius adopte la première perspective dans son commentaire de la *Physique*, et la seconde dans son commentaire du *De caelo*. Au reste, il reconnaît explicitement, dans un autre texte du commentaire de la *Physique*, que les deux concepts d'extension et d'indivisibilité, qui pour lui comme pour Aristote sont inconciliables, coexistaient dans la représentation primitive de l'atome selon Démocrite.

Tout autre est l'esprit qui anime la *Collection* d'Aétius. Fruit de rédactions successives des écrits historiques de Théophraste, ce recueil présente de multiples déformations de la pensée présocratique, particulièrement de la pensée atomiste. En témoigne, entre autres, accolée à la négation générale de la pesanteur des atomes, cette affirmation que pourrait exister un atome «grand comme un cosmos». Aristote affirme expressément que les atomes étaient si petits qu'ils n'atteignaient pas le seuil de la perception. L'affirmation contraire d'Aétius se fonde très probablement sur une compréhension erronée de la variété infinie que Démocrite postulait dans les figures des atomes. En effet, selon Lucrèce, la figure d'un atome s'expliquerait par la disposition de ses «parties»: une variété infinie de figures supposerait par conséquent un nombre infini de «parties», donc une augmentation infinie de grandeur. L'atome d'Aétius, «grand comme un cosmos», est sans doute issu du même raisonnement que l'atome de Lucrèce, doté «d'une immense étendue».

Les historiens modernes, quant à eux, sont tentés par la médiocrité d'un juste milieu entre ces extrêmes, que sont d'un côté l'atome «gros comme un cosmos» d'Aétius, et de l'autre les atomes d'Aristote, imperceptibles par leur petitesse; ils

optent ainsi pour des atomes de «grosseur moyenne». En réalité, aucun compromis ne permet d'harmoniser sur ce point le témoignage d'Aristote et celui d'Aétius. Il faut trancher. Aétius ou l'un de ses prédécesseurs s'est emparé de concepts en l'occurrence tout-à-fait anachroniques, sans doute pour enrichir ses connaissances de Démocrite; les affirmations contraires d'Aristote, et l'allusion aux «parties» des atomes dans le raisonnement de Lucrèce, sont une preuve patente de la fausseté de sa notice.

La conclusion qui s'impose quant à la grandeur des atomes s'impose également quant à leur pesanteur. Aétius est tributaire des écrits historiques de Théophraste, au même titre que Simplicius. Si Simplicius ne sait rien d'une absence de pesanteur dans les atomes non-cosmiques, il est fort peu probable qu'Aétius en ait puisé la connaissance à leur source commune. Derrière son témoignage, l'historien n'a pas à détecter une source nouvelle, mais bien une erreur: celle même d'Alexandre. L'absence d'un mouvement naturel, au sens aristotélicien de ce terme, lui fait croire à l'absence de pesanteur.

Chapitre XI—

Le traité d'Aristote «Sur Démocrite» et son exploitation par Simplicius

Peut-on cerner de plus près les documents dont se servait Simplicius? Le texte du commentaire de la *Physique* (le mouvement des atomes «selon la pesanteur») se rapproche par plus d'un trait d'une longue citation du traité d'Aristote *Sur Démocrite*, rapportée par Simplicius dans son commentaire du *De caelo*. Aristote ne parle pas ici de pesanteur: il affirme toutefois que le mouvement des atomes dans le vide serait le fait de leur différences de taille et de figure. Simplicius a-t-il pu croire—a-t-il pu savoir?—que les différences de taille comportaient dans ce contexte une différence de poids?

Taille, figure, poids: aucun de ces trois facteurs ne saurait entraîner une différence de vitesse, selon les arguments développés par Aristote, dans la *Physique*, contre la possibilité du mouvement dans le vide. Une différence de taille et de figure dans les atomes était liée, pour Démocrite, à une différence de mobilité et de vitesse: la différence de poids l'était-elle aussi? Ces trois facteurs dans l'argumentation de la *Physique* viseraient-ils la théorie de Démocrite?

Certes, dans la *Physique*, le corps le plus gros a le mouvement le plus rapide. Pour Démocrite, au contraire, les atomes les plus petits sont aussi ceux qui vont le plus vite. Mais le rapport vitesse/légèreté se retrouve dans le *Timée*; il fait l'objet d'une critique de la part d'Épicure; à en croire Plutarque, il appartient au patrimoine commun des «hommes sages de l'antiquité». Faut-il compter Démocrite parmi ceux-ci?

Chapitre XII—

Conclusion: la pesanteur des atomes

Même si certaines des questions posées au chapitre précédent doivent rester sans réponse, des résultats définitifs semblent désormais acquis au terme de cette enquête. On ne saurait en effet douter qu'il faille accorder plus de crédit aux exégèses d'Aristote, de Théophraste et de Simplicius qu'à la notice d'Aétius. Nous en tirons deux conclusions, qui se situent à des niveaux de certitude différents. Conclusion minimale: s'il n'a pas refusé une pesanteur aux atomes non-cosmiques, Démocrite n'a pas toutefois précisé la fonction qu'il lui accordait. Conclusion maximale: la pesanteur des atomes non-cosmiques s'expliquerait par leur choc et leur différence de vitesse, les atomes les plus légers étant aussi les plus rapides.

Nous souhaitons que ces deux conclusions, quelque ponctuelles et limitées qu'elles soient, puissent mettre le point final à l'un des problèmes les plus épineux dont sont de l'histoire de la pensée présocratique.

Chapitre XIII—

Nouvelles perspectives sur les conceptions de la pesanteur chez les présocratiques

Quelques réflexions s'imposent au terme de cette étude, et qui donneront à l'enquête menée ici sa portée véritable et plus vaste.

À suivre le cheminement des historiens de la philosophie présocratique, une double réaction s'impose: ne pas se laisser absorber par la polémique, ne pas se laisser obnubiler par le principe d'une autorité reçue. «Personne dans l'Antiquité n'a entendu par pesanteur autre chose que la propriété par laquelle les corps se dirigent de haut en bas, si rien d'extérieur ne les en empêche.» C'est ainsi que Zeller définissait la pesanteur. Or cette définition ne correspond ni à la théorie de Platon ni à celle d'Aristote. Zeller n'a cité aucun document pour l'appuyer. Et pourtant on continue d'en faire la pierre de touche de toute interprétation d'une théorie de la pesanteur selon Démocrite. On voit dès lors par quel paradoxe les historiens de la philosophie présocratique, tout en polémiquant contre Zeller, ont accepté sa définition sans jamais la révoquer en doute.

Une fois détruit ce préjugé, on peut dégager des documents une tout autre conception du phénomène de la pesanteur. Pour les penseurs présocratiques, en effet, la pesanteur ne se caractérisait pas principalement par des différences de lieu ou de mouvement, comme ce sera le cas plus tard pour Platon et Aristote. Le lourd et le léger se rangeaient plutôt du côté des autres «pouvoirs», le chaud et le froid, le lumineux et l'obscur. C'est Plutarque qui l'affirme, lequel avait sur nous l'avantage de posséder une plus large connaissance des premiers philosophes.

Certes, selon Théophraste, le lourd et le léger se traduisaient aussi par des mouvements vers le bas et vers le haut. Mais, selon le même auteur, ces différences de mouvement étaient en quelque sorte subordonnées à des différences de densité: sont «épais» le froid, l'obscur, le lourd; sont «rares» («peu denses») le chaud, le lumineux, le léger.

Voilà retrouvé le point de départ de Démocrite. quelle est donc son originalité? Avec une marge d'interprétation, bien sûr, mais en s'en tenant à une extrême simplicité—signe peut-être d'authenticité—on pourrait reconstituer ainsi sa démarche. Les corps composés, en raison du plus ou moins de vide, varient en densité: celui qui avait davantage de vide, donc le plus «rare», serait aussi le plus léger. En revanche, les atomes pris isolément ne peuvent varier en densité—ils ne peuvent être ni plus «épais» ni moins «épais»—mais ils varient en grosseur: l'atome le plus gros est donc le plus pesant. La définition de la pesanteur en termes de mouvement ne verra le jour que plus tard. Mouvement et lieu ne peuvent déterminer le concept de pesanteur que dans un monde unique et éternel, ce sera celui de Platon et d'Aristote.

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